ECONOMIC GEOLOGY

WITH WHICH IS INCORPORATED

THE AMERICAN GEOLOGIST

VOL. XV JUNE, 1920 NO. 4

NOTES ON THE COAL INDUSTRY OF NORTHEASTERN FRANCE, BELGIUM, THE SAAR, AND WESTPHALIA, 1904–1913.

THE COAL INDUSTRY OF NORTHEASTERN FRANCE, BELGIUM, THE SAAR DISTRICT AND WESTPHALIA FOR THE PRE-WAR DECADE, 1904-1913.

H. F. CROOKS.

Introduction.

The following notes represent a summary of data on the coal mining industries of northeastern France, Belgium, the Saar District, and Westphalia, collected by the writer and others together with similar data on iron ore, from French, German, and Belgian sources in Paris, and embodied in a report to the American Commission to Negotiate Peace, by Alfred H. Brooks and M. F. La Croix.[1] (See Fig. 35.)

It is not contended that any of these data are new, but they represent a digest of data scattered through eight hundred reports, and they have not been similarly assembled heretofore in the French, German, or English literature. To realize fully the vital importance of the coal industries to the countries in ques-

[1] Brooks, Lt. Col. A. H., Engrs. U. S. A., La Croix, Maj. M. F. "Reports on the Iron, Steel, and Associated Industries of Lorraine, the Saar District, Luxembourg, and Belgium." American Commission to Negotiate Peace, War Damages Board, Section of Mines and Metallurgy, Paris, April 15, 1919.

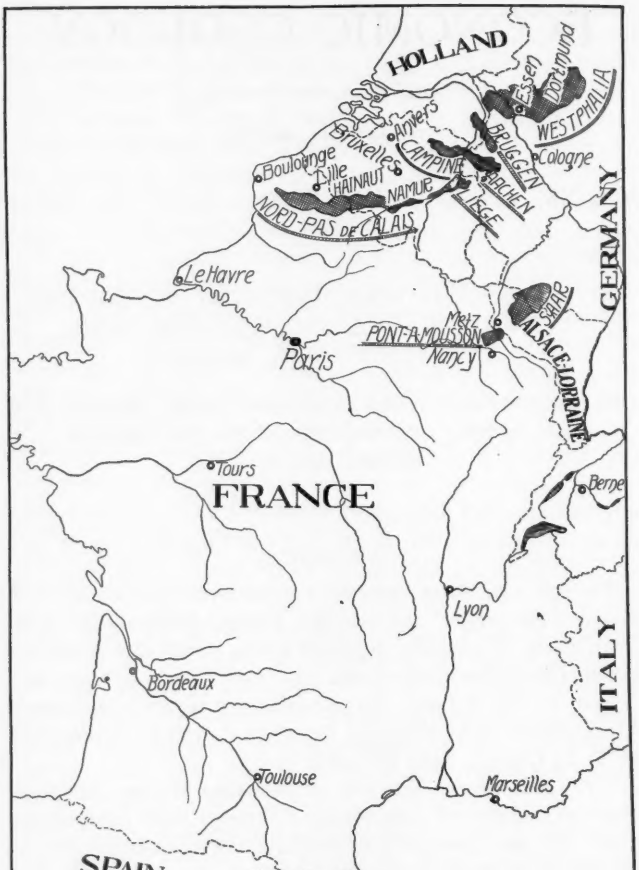

FIG. 35. Bituminous coal basins of northern France, Saar, Westphalia, and Belgium.

tion, in relation to the metallurgical industries, attention is called to an article on the subject by Brooks and La Croix.[2]

While there are other uses for coal than in the metallurgic industries, its consumption for those purposes is the greater percentage of the production, and since these industries form the economic backbone of the countries in question, the treatment of the coal industries is from that standpoint.

The writer is indebted to the bibliothècaires of the Haute Ecole des Mines and Comité des Forges de France, Paris, for placing their resources at his disposal, as well as to Lt. Col. Brooks for suggestions on the treatment of the subject, and to Dr. W. S. Bayley for reading of the manuscript.

The discussion of French coal is limited to the northeastern fields. This is because of the fact that the most extensive deposits of coal are there located, that the production of the region is about 80 per cent. of all France, and that the metallurgic plants situated within it, as well as most of those of the Briey-Longwy area, the Loir, and in the vicinity of le Creusot are supplied with coal and coke from the Nord and Pas-de-Calais fields.

The best published estimates of the coal reserves of Europe are those given at the Toronto meeting of the International Geological Congress in 1913. These estimates are only approximations but may be considered fairly accurate as far as the large European nations go, for very careful records of annual production have been kept since the beginning of the twentieth century, and these together with drill records have enabled engineers to carefully outline boundaries of actual reserves and thus note their diminishment. The table of reserves which follows includes anthracite as well as bituminous coal, both being actual reserves to a depth of 2,000 meters (4,000 feet). Of the total reserves in 1913, England had 49.4 per cent.; Germany, 34.6 per cent.; France, 1.6 per cent.; Belgium, 4.0 per cent.; Spain, 2.2 per cent.; Austria, 1.1 per cent.; and the remainder of Europe, 7.1 per cent. The paucity of the French reserves in comparison to those of Germany is well shown.

[2] Brooks, A. H. and La Croix, M. F., U. S. Geol. Survey Bull. No. 703 (in press). "Iron and Steel Industries of Lorraine, the Saar District, Luxembourg, and Belgium." 1920.

In this paper areas are in hectares (2.47 acres), lengths in meters (3.28 feet), weights in tons of 1,000 kilograms (2,205.48 lbs.), and money values in francs and marks (1 franc = $0.193; 1 mark = $0.25).

TABLE I.

EUROPEAN RESERVES OF COAL (ACTUAL) 1913 (METRIC TONS) (0—2000 M.).

Germany		
Westphalia	71,213,000,000	
Saar	16,548,000,000	
Remainder	7,104,000,000	
Total		94,865,000,000
France		
Nord and Pas-de-Calais	3,790,000,000	
Remainder	413,325,000	
Total		4,203,325,000
England (Eng., Scot., Wales, Ireland)		135,292,569,000
Belgium		
Hainaut } Liège }	3,000,000,000	
Campine	8,000,000,000	
Total		11,000,000,000
Spain		6,220,000,000
Austria		2,770,000,000
Remainder of Europe		19,638,106,000
Grand Total		274,189,000,000

The figures of Table I. are shown diagrammatically in Fig. 36 which follows.

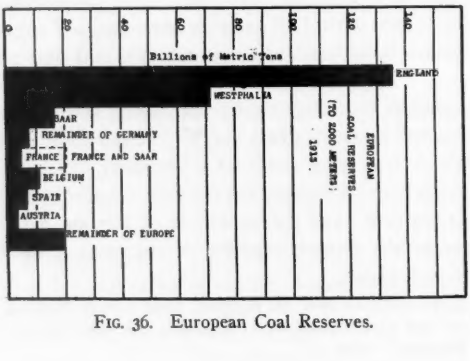

FIG. 36. European Coal Reserves.

THE COAL INDUSTRY OF NORTHEASTERN FRANCE.

General.—Productive coal bearing areas of the northeastern part of France in the Departments of Pas-de-Calais and the Nord extend in an east-west direction from the vicinity of Aire-sur-la-Lys, through Bèthune, Lens, Douai, and Valenciennes to the Belgian frontier (Fig. 35). A network of canals and railroads traverse the area, furnishing alike excellent means of transport to the interior, the English Channel, and Belgium. Unlike the Belgian mines, which the Germans operated after the establishment of position warfare and whose surface works are only partially destroyed, the majority of the French mines in the Bèthune and Lens regions have not only had their surface works damaged by battle fire as well as by wanton destruction, but have suffered underground wrecking and flooding to such an extent that it is not thought they can be re-established fully on a pre-war basis before 1921.

Besides the two coal-bearing areas above mentioned, there is in the Pont-à-Mousson region a continuation of the Saar coal field which has been discovered by drilling, but which is not yet exploited. Although it covers an area 15,000 hectares, the beds have only an aggregate thickness of 0.65 to 6.3 meters. Therefore, its reserves will be an unimportant asset to the metallurgic industry of the Minettegebiet.

Geologic Features.—Coal in northeastern France occurs in the Westphalian series of the Carboniferous system. Taken in their assembly, the coal formations become thicker from east to west in the direction of extent of the basins, and thicken in the transverse direction from north to south. The diastrophic movements affecting the South Basin of Belgium likewise affected the Nord and Pas-de-Calais basins of France, the areas being delimited both on the north and south by east-west trending thrust faults of considerable magnitude. Under the influence of these movements the southern part of the basins was folded, elevated, and refolded on itself. To complicate the structure, the entire width of the basin is cut by minor radial faults of the fantail type. The result of these movements is that the coal measures dip toward the south

at from 20° to 50°. Coal of anthracite grade is mined along the northern border of the basins, while there is a progressive increase in volatile matter content of the coal mined toward the south.

The Bassin de Pont-à-Mousson contains coal similar to that of the Saar district, that is to say, of inferior coking value. The coal occurs in the lower part of the Ottweiler stage of the Stephanian series, and in the Saarbrücken stage of the Westphalian series, that of the latter and lower series being of the coking variety while that of the former is generally anthracitic. It is found at depths ranging from 659 to 1,487 meters, and is in thin seams varying from a few centimeters to one and one half meters in thickness. The beds lie along an anticline and have variable dips from 8° to 50° toward the west, those of the highest coking value having the lower dips. Generally speaking, this coal horizon of the Pont-à-Mousson basin is of poorer quality than that of the Saar district.

Geographic Distribution.—The Bassin du Nord occupies that area between the Belgian frontier and the promontory d'Auby, having a length of 45 kilometers and a width of 15 to 20 kilometers. It is divided into three regions from east to west: (*a*) Valenciennes; (*b*) Denain; (*c*) Douai.

The Bassin du Pas-de-Calais is the westward extension of the Bassin du Nord, and extends from the promontory d'Auby on the east to Flèchinelle on the west, a distance of about 58 kilometers. It has been divided into three regions, each separated from the others by faults; they are: (*a*) Centrale; (*b*) Nord; (*c*) Sud-Ouest.

The Bassin de Pont-à-Mousson, which was discovered by drilling in 1903, is situated just south of the Briey-Longwy iron ore district with the city of Pont-à-Mousson as its center. The development of this basin will be slow in consequence of the depth of mining and to attendant difficulties arising from the presence of water-bearing overlying sediments with strong artesian flows. Table II. shows the kinds of coal produced in each district.

TABLE II.

Bassin du Nord.

Region.	Location of Area.	No. of Veins.	No. of Mines in Operation 1912.	Thickness of Coal, Meters.		Average Depth of Mining, Meters.	Kind of Coal Produced.
				Ave.	Max.		
Valenciennes	Between Belgian frontier and Valenciennes						
Condè....	Environs of Condè...	10	4	7.15	7.60	270	Anthracite.
Thiers....	Environs of Thiers...	17	4	11.40	12.80	390	Long-flame, short-flame, semi-bituminous, anthracite.
Denain	Between Valenciennes and Aniche						
d'Arenberg.....	Near d'Arenberg & de Sessevalle.....	9	20	6.25	6.50	205	Anthracite.
Aniche....	Near Abscon and Aniche.....	9	11	6.00	7.30	285	Semi-bituminous.
Douai	Between Aniche and Pas-de-Calais						
	North of Douai.....	25	2	17.00	23.00	800	Semi-bituminous, short-flame.
	South of Douai.....	38	7	24.90	27.00	1,100	Short-flame, long-flame.

Bassin du Pas de Calais.

Centrale							
Lens	Region of Lens and Liévin.....	12	20	11.75	21.00	325	Short-flame, long-flame, gas coal.
Dourges ..	East of Lens.....	29	8	27.50	38.00	693	Short-flame, long-flame, gas coal.
Noeux....	Vicinity of Noeux....	17	19	13.50	17.30	410	Short-flame, long-flame, gas coal.
Bully-Grènag ..	Between Noeux & Lens	15	15	13.30	14.20	345	Long-flame, gas coal.

Region.	Location of Area.	No. of Veins.	No. of Mines in Operation 1912.	Thickness of Coal, Meters.		Average Depth of Mining, Meters.	Kind of Coal Produced.
				Ave.	Max.		
Nord							
Ostricourt.		12	22	8.75	9.00	420	Anthracite.
Sud-Ouest							
Bruay....	Vicinity of Bruay, Marles and Ferfay ..	25	14	23.10	28.28	442	Long-flame, gas coal.
Flèchinelle	Flèchinelle.....	18	4	14.00	....	350	Long-flame, gas coal.

Classification of Coal.—The classification of French coal is similar to that of Belgian, amplified to include coal of high gas content. Table III. gives the relations:

TABLE III.

(F) Charbons gaz., with more than	32% V.M.		Bituminous (U.S.)
(F) Charbons gras flambant, with .....26–32% V.M.		Short Flame coal	
(B) Charbons Flénus Secs., with more than	25% V.M.		
(F) Charbons gras à coke, with .....17–26% V.M.		Long Flame coal	
(B) Charbons Flénus gras, with .....16–25% V.M.			
(F) Charbons demi-gras, with .....12–17% V.M.		Semi-Bituminous	
(B) Charbons demi-gras, with .....11–16% V.M.			
(F) Charbons Maigres and Anth., less than	12% V.M.	Anthracite	Anthracite (U.S.)
(B) Charbons maigres, less than	11% V.M.		

(F) France; (B) Belgium.

Labor.—The French introduced foreign labor, for the most part Italians and Germans, and while no statistics are at hand to indicate the per cent., it is said[3] that they represent about forty per cent. of the total (203,306) mine laborers.

The average annual wage for all classes of employees in 1913 was 1,452 francs, which for three hundred working days in the year gives 4.99 francs per day.

The average annual production per individual in 1913, for all of France, was 199 metric tons.

The number of concessions exploited in France decreased from

[3] Commandant Edgar Parlongue, Belgian Army. (Oral statement to writer.)

290 in 1904 to 245 in 1913, due to exhaustion of reserves and to lack of demand for coal of the quality mined. The average annual production per individual increased from 199 tons in 1904 to 203 tons in 1912, then dropped to 197 tons in 1913; the fluctuation being due to variations of supply and demand rather than to decreased individual efficiency.

Production, Costs, and Profits.—In 1913, 326,347 hectares of concessions were being worked by 232 mines; of these, 138 showed a total net profit of 74,528,050 francs, while 94 showed a loss of 27,578,050 francs. In Table III. the average selling price per ton at the mine is taken as the value quoted by the Coal Exchange (Carreau des Mines).

TABLE III.

COST, AVERAGE SELLING PRICE, AND PROFIT OF COAL (1912 AND 1913).

	1912		1913	
	Francs.	Per Cent. of Av. Selling Price.	Francs.	Per Cent. of Av. Selling Price.
Total cost	14.42	92.71	15.38	92.26
Selling price at mine	15.51	100.00	16.55	100.00
Profit	1.09	7.29	1.17	7.74

Production of Coal.—The increase in production between 1904 and 1913 of only seven million metric tons serves in a measure to indicate not only the intensiveness of mining operations but the poverty of France in coal. It is this poverty, which, in view of her extensive metallurgical industries, casued an increase for the decade to imports of nine million tons in 1913, equalling about 50 per cent. of the production for that year. (See Fig. 37.)

TABLE IV.

FRENCH COAL PRODUCTION (METRIC TONS).

Year.	No. Mines.	Total Production.				Mean Value per Ton (Francs).
		Nord.	Pas de Calais	Rest.	France.	
1904	290	5,905,900	15,812,400	11,784,100	33,502,400	13.30
1907	276	6,362,900	17,216,400	12,409,600	35,988,900	14.97
1909	254	6,522,200	18,409,400	12,184,300	37,115,900	15.22
1911	258	6,646,900	19,493,000	12,380,900	38,520,800	15.24
1913	232	6,814,000	20,575,000	13,455,000	40,051,000	16.55[4]

[4] The cost of mining for 1913 was 13.19 francs.

Imports and Exports.—French exports of coal are very small due to her own needs; they average about 1,500,000 metric tons per year for the decade.

Imports represent about fifty per cent. of the annual production, with England and Belgium as the principal sources. The metallurgic industries of the Nord and Pas-de-Calais basins are supplied from local sources, but those of Lorraine rely almost entirely on coal and coke imported from Belgium, the Saar district, and Westphalia; the large English imports being used for the littoral metallurgic plants, and for other industrial and domestic purposes. With the acquisition of the Saar coal fields these imports will be reduced somewhat; however, for Lorraine iron ore, Westphalian coke must always be mixed with that of the Saar for smelting purposes, so it is seen that the reduction will not be important.

TABLE V.

SOURCES OF COAL USED IN FRANCE (METRIC TONS).

	1904.	1910.	1913.
Total French production	33,502,400	37,634,900	40,051,000
Imports from Germany	2,420,000	4,577,000	6,673,700
" " Belgium	4,953,000	5,382,000	4,397,500
" " England	7,183,000	9,919,000	11,270,000
" " Other countries	6,000	14,000	452,600
Total imports	14,562,000	19,892,000	22,793,800
Total French consumption	47,030,000	56,530,000	61,458,200

Reserves.—The coal reserves of France as given by Defline[5] are the only figures available, and unfortunately they do not separate the northeastern area into basins. However, it is known that the reserves of the Bassin du Pas-de-Calais far exceed those of the Nord in all grades as well as in coking coal reserves. The larger area of reserves are along the southern borders of the basins. Estimates of the Pont-à-Mousson basin show probable reserves of 300,000,000 tons of coal of over seventeen per cent. volatile matter content. Development of this area will increase this figure somewhat. Table VI. shows that 91 per cent. of long

[5] Defline, M., "Coal Resources of the World." 12th Int. Geol. Congress, Toronto, 1913.

flame coal reserves, 94 per cent. of coking coal reserves, and 90 per cent. of the semi-bituminous and anthracite reserves are con-

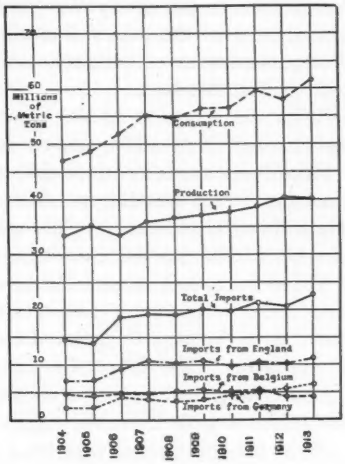

FIG. 37. French Production, Consumption, and Imports of Coal.

fined to the northeastern fields. The figures given are for actual reserves only.

TABLE VI.

FRENCH COAL RESERVES, 1913 (METRIC TONS).

Basin.	Long Flame.	Short Flame.	Semi-bituminous and Anthracite.	Remarks.
Nord-Anzin.....	1,680,000,000	1,010,000,000	1,100,000,000	Actual above 1,200 m.
Remainder of France..	172,120,000	61,205,000	156,950,000	Actual above 1,200 m.
Total.....	1,852,120,000	1,071,205,000	1,256,950,000	

Commercial Use of French Coal.—France consumes as coke in her metallurgical plants about eleven per cent. of the coal mined; of this figure, a minor portion goes to the Lorraine blast furnaces, the major part being used to smelt Lorraine ore in the northern furnaces. In 1913, the northern French fields supplied

the Lorraine plants with 1,596,000 tons of coke and 400,000 tons of coal, against 2,478,800 tons of coke and 1,814,700 tons of coal received from other sources, principally Westphalian. The steel plants and blast furnaces of the *massif centrale* and the lower Loire consume large quantities of both coke and coal, supplied almost entirely from French sources.

Conclusion.—With the accession of the Saar coal fields the French reserves increase from 4,180,300,000 tons to 20,728,-300,000 tons. This causes one to conclude that an ample supply of coke is assured for French metallurgy. That such a conclusion is premature will be shown later, for Saar coal is of inferior coking quality for blast furnace practice unless mixed with Westphalian coke. The development of the Pont-à-Mousson basin will add but little to the French supply, therefore, France must turn in the future, as in the past, to coal and coke from Westphalia for her furnaces. Coal from the Campine basin of Belgium is of good coking quality, and with the establishment of transportation relations with Lorraine, freight rates between these localities will be able to compete with those between Westphilia and the latter, and thus tend to equalize prices of Campine and Westphalia coke.

THE COAL INDUSTRY OF BELGIUM, 1904–1913.

General.—There are two well-defined coal-bearing areas in Belgium: the South Basin, also known as the Bassin du Haine-Sambre-Meuse, a continuation of the Bassin du Nord of France, continuing in turn into Prussia as the Aachen field; and the North Basin, or Bassin du Campine, an area but recently explored by drilling and unproductive as yet (see Fig. 35).

Geological Features.—Belgian coal occurs in the lower Namurien and upper Westphalian series of the Carboniferous system. It is thought by Renier[6] to have been deposited in the Carboniferous channel of the Haine River. Subsequent denudation has removed a portion of the covering of post-Paleozoic

[6] Renier, A., "Les Resources Houilleres de la Belgique," Congres Gèologique International, Toronto, Canada, 1913, Coal Resources of the World, Volume II., p. 802.

rocks, leaving the coal measures within easy access of the surface. Shortly after the close of the Carboniferous, diastrophic movements of the Hercynienne phase caused folding and faulting of the coal-bearing strata, leaving them in a geosyncline complicated with minor east-west plications, cut by numerous faults parallel to the synclinal strike, and by radial faults which open toward the south in the form of a fantail.

Geographic Distribution.—The South Basin underlies the provinces of Hainaut, Namur, and Liege; it is divided into districts in each province. The North Basin lies in the provinces of Limbourg and Anvers. The various districts, and the kinds of coal produced in each are shown in Table VII.

The North Basin (*Bassin du Campine*).—The only develop-

TABLE VII.

SOUTH BASIN.

Province.	District.	No. of Mines in Operation 1913.	Thickness of Seam (Meters).		Ave. Depth of Mining (Meters).	Kind of Coal Produced.
			Ave.	Max.		
Hainaut.	Mons (*a*) . . .	24	0.55	1.70	. . .	Long- and short-flame (coking).
						Semi-bituminous.
	Centre (*b*) . .	11	0.65	. . .	450	Long-flame (limited).
						Short-flame (coking).
						Semi-bituminous.
	Charleroi (*c*)	13	0.70	. . .	550	Short-flame (coking) near Charleroi. Semi-bituminous near Charleroi. South of Sambre R. coking and forge coal.
						Anthracite in east part.
Namur. .	Namur (*d*) . .	12	0.75	. . .	. . .	Semi-bituminous, low grade.
						Anthracite, low grade.
Liege . . .	Liege (*e*) and Hervé	43	0.45	1.80	450	Short-flame (coking).
						Semi-bituminous.
						Anthracite.

Location of areas: (*a*) "Couchant de Mons" or "Borinage" lies between French frontier and Mons.

(*b*) The *Bassin du Centre* lies between Mons and Charleroi; bounded on north by the Brussels Canal, and on south by Sambre River.

(*c*) From Charleroi to eastern boundary of Hainaut.

(*d*) Basin is very narrow. Depth less than that of either Hainaut or Liege.

(*e*) District extends from east to west boundaries of province and continues on east as the Aachen field in Prussia.

ment of the Campine basin, since its discovery in 1901, has been by drilling. The coal-bearing area occupies the north-central part of the Province of Limbourg, and has been followed into the central part of the Province of Anvers. From northwest to southeast its approximate length is 90 kilometers, and its width is from 12 to 16 kilometers. The conceded territories cover an area of 315 sq. km., while the zone of reserves covers an area of 195 sq. km.[7] The thickness of the overburden, varying from 370 meters in the southeastern part to 1,000 meters along the northern extremity in Limbourg, together with its water-soaked character will make rapid development difficult.

In 1913, twelve shafts were being sunk by seven companies, but up to the outbreak of the war none of these had been bottomed. After conditions of the German occupation stabilized work continued, but was slow due to heavy inflow of water from overlying strata. However, early in 1919 several of these mines began to produce in limited quantity. Drill logs show the beds, though thin, to be very regular and persistent. Their inclinations vary from a few degrees to a maximum of thirty-five degrees. According to the *Annales des Mines de Belgique*[8] the Campine Basin consists of the following beds:

Numbers of Beds.	At a Depth of (Meters).	Number of Exploitable Beds.	Mean Total Thickness of Coal in Exploitable Beds (Meters).	Percentage of Exploitable Coal (%).	Per Cent. Volatile Matter (%).
I.	500	10	8.00	1.60	35–40
II.	280	10–14	9.00	3.20	32–47
	240	11–18	11.60	4.80	22–38
III.	160	4– 5	3.40	2.10	18–30
IV.	160–200		barren		
V.	380	5– 7	4.00	1.05	12–26
Productive Beds Explored.					
II. and	1,760	46	36.00	2.00	12–47
III.–IV.	700	30	24.00	3.40	18–47

Classification of Coal.—The classification of Belgian coal is based upon the volatile matter content, all coal containing more

[7] Renier, A., *idem*, p. 816.

[8] Tome XIV., 1er Livraison, 1914, p. 18.

than eleven per cent. volatile matter being included in our term bituminous, while that with less than eleven per cent. corresponds more or less closely with our anthracite. This relation is best shown as follows:

Charbons Flénus secs. contain more than 25% V.M.=Long flame Charbons Flénus gras contain .....16–25% V.M.=Short flame Charbons demi-gras contain .....11–16% V.M.=Semi-bitum.	Bituminous (U. S.)
Charbons maigres contain less than ... 11% V.M.=Anthracite	Anthracite (U. S.)

Labor.—Most of the laborers in the Belgian coal fields are Belgian, thus contrasting with the German and French practice in the use of foreigners in their mines. In 1913, the total was 145,337.

The average daily wage for all classes of workmen in the various districts was, in 1913, 5.17 francs. The number of days of work in the same year was 298.

Underground conditions, depth of mining, etc., as well as the character of surface equipment determine to a large measure the annual production per individual; it varies from year to year, depending somewhat on the intensiveness of operations. In 1913, it was 157 metric tons.

TABLE VIII.

Per Ton.	1906–1910.		1912.		1913.	
	Francs.	Per Cent. of Average Selling Price.	Francs.	Per Cent. of Average Selling Price.	Francs.	Per Cent. of Average Selling Price.
Total cost.....	14.04	91.11	16.22	97.94	17.51	95.48
Average selling price	15.41	100.00	16.56	100.00	18.34	100.00
Profit.....	1.37	8.89	0.34	2.06	0.83	4.52

Production, Costs, and Profits.—In 1913, there were 126 mines in operation; of these, 75 showed a total net profit of 33,905,100 francs, while 51 showed a loss of 14,960,050 francs. Table VIII. shows the cost, average selling price, and profit per ton of coal for the years indicated.

Production of Coal.—As will be seen from an inspection of Table IX., the coal production for the pre-war decade was ap-

TABLE IX.

BELGIAN COAL PRODUCTION (METRIC TONS).

Year.	Long Flame.	Short Flame.	Semi-bitum.	Anthracite.	Total Production.
1904.....	2,409,970	5,948,070	10,492,250	3,911,140	22,761,430
1907.....	2,454,660	6,092,500	10,215,420	4,942,610	23,705,190
1909.....	2,243,210	6,028,280	10,268,100	4,977,960	23,517,550
1911.....	2,387,800	5,859,550	9,631,010	5,175,180	23,053,540
1913.....	2,110,790	5,453,626	9,715,610	5,561,570	22,841,590

proximately at the rate of 23,000,000 metric tons per year; fluctuations being due principally to variation in economic conditions, abandonment of mines because of exhaustion of reserves, and the delay attendant upon the opening up of new mines. It is thought that the opening of new mines in the Campine Basin together with the installation of modern machinery to replace that destroyed by the Germans in the South Basin will enable Belgian mines rapidly to re-establish normal production, and by 1920, to show the annual increase usual under favorable economic conditions. A glance at Table IX. will show that in the Mons and Centere districts, the production of long-flame coal declined fourteen per cent. between 1904–1913, as did also that of short-flame coking coal, particularly in the Liége district where the developed reserves are becoming exhausted; this decrease for the decade in the latter area being nine per cent. of the 1913 production. Semi-bituminous production remained approximately constant, while that of anthracite coal showed an increase of twenty-seven per cent. of the 1913 production for the decade, this being due to increases in both the Liége and Charleroi districts.

An inspection of Fig. 38 shows a very constant coal production up to 1910; the decrease is caused not only by diminution of reserves, but by refined metallurgic practice involved in the use of Westphalian coal as coke. Imports from England were largely for domestic purposes, while those from France were for industrial use by the frontier plants.

Coal Imports and Exports.—In spite of the fact that Belgium produces large quantities of good coking and domestic coals, she was forced to import considerable tonnage from England, France,

and Germany. This importation, in 1913, was thirty-nine per cent. of the production, twenty-two per cent. of this being used expressly in the manufacture of coke. These imports came chiefly from the Westphalian and Aachen districts in Germany. (Table X.)

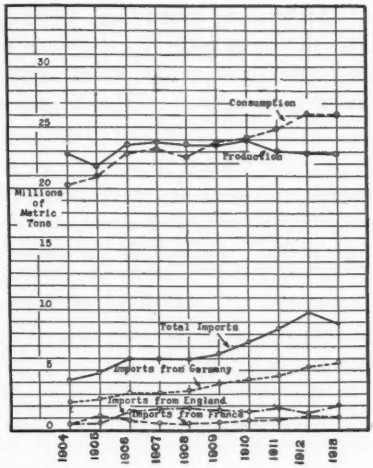

FIG. 38. Belgian Production, Consumption and Imports of Coal.

TABLE X.

SOURCES OF COAL USED IN BELGIUM (METRIC TONS).

	1904.	1910.	1913.
Total Belgian production	22,761,430	23,916,560	22,841,590
Imports from Germany	2,311,094	4,213,918	5,728,406
" " France	664,000	795,000	811,000
" " England	614,242	1,704,880	2,031,077
" " Other countries	604,534	629,382	285,670
Total imports	4,193,870	7,343,180	8,856,153
Total Belgian consumption	20,228,577	24,126,460	26,046,094

Reserves.—Statistics on the coal reserves of Belgium given by Renier at the meeting of the 12th International Geological Congress in 1913 are the only ones available. While the coal-

bearing areas have been well-defined by drilling, the complicated structure together with the lack of continuity of given horizons make generalities the only possible method of estimation. In the South Basin, by far the largest percentage of reserves are in the western part of the Province of Hainaut near the French frontier, in the north-central part of the Mons Basin, and Bassin du Centre. East of Charleroi and in the Liége district, there are no significant reserves of coking coal. The estimates of reserves in the Campine Basin show it to contain about eighty per cent. of the total estimated Belgian reserves. Table XI. shows the figures in detail:

TABLE XI.

BELGIAN COAL RESERVES (METRIC TONS).

Province.	Long Flame Coal.	Short Flame (Coking) Coal.	Semi-bituminous and Anthracite.	Above Depth of Meters.
South Basin				
Hainaut	500,000,000	1,000,000,000	900,000,000	1,200
Liége and Namur	.....	100,000,000	500,000,000	1,200
Campine Basin				
Limbourg	3,600,000,000	2,900,000,000	500,000,000	1,500
Anvers	.....	1,000,000,000	.....	1,500
Total	4,100,000,000	5,000,000,000	1,900,000,000	

Commercial Use of Belgian Coal.—Aside from the use of coal for domestic purposes, the manufacture of coke and briquettes is the most important use of Belgian coal. In spite of the country's poverty in iron ore, the metallurgical industry is the most important of Belgium. This is due to the contiguous location of the Minettegebeit, to the cheapness of smelting costs, and to the excellent systems of canal and rail transport with attendant low haulage charges between the iron mines and the coal fields.

Conclusion.—It has been shown that Belgium's future so far as coal is concerned lies in the Campine fields. Even with this area well developed, it is doubtful whether the coke produced will be able to compete with that from Westphalia. The demands of the iron and steel industries draw heavily on the coal production,

and, with the acquisition of Lorraine Annexée by the French, Belgian blast furnaces will be called upon to increase their outputs, which mean a possible thirty per cent. increase of coke consumption. The haul from the Saar fields is too expensive to permit coal from that region being counted upon; so until the Campine is developed, startling increases in imports of German coke must be looked for.

THE COAL INDUSTRY OF THE SAAR DISTRICT (1904–1914).

General.—The Saar District, or Saarbezirk, is the third largest of Germany's coal fields, both from the standpoint of reserve as well as production. Its mines are controlled by two interests, the State, and by private corporations. The former owns fourteen mines of which twelve belong to the Kingdom of Prussia and two to the Kingdom of Bavaria. The private corporations own six concessions as follows: Frankenholz, owned by the French; Hostenbach, owned by a Prussian-Rhenish organization; one owned by a Bavarian Palatinate corporation; and three others in Lorraine, namely, La Houve, Petite Rossele, and the Saar-et-Moselle, all of French, or mixed French and German capitalization.

In this paper, the Saar District is understood to include Bavarian Pfalz, Lothringen, and that part of the grand duchy of Baden underlain by coal measures.

Table XII. gives the approximate areas of coal lands owned

TABLE XII.

COAL LAND OWNERSHIP IN THE SAAR FIELD, 1913.

Owned by	Rheinland (ha.).	Bavarian Palatinate (ha.).	Lorraine Annexed (ha.)	Total Area (ha.).
Government	110,000	4,370	.....	114,370
Private corporations	112	630	42,570	43,312
Totals	110,112	5,000	42,570	157,682

by the government, and also those concessions controlled by private corporations. In addition to the lands listed, there is evidence that there may be coal under 100,000 additional hectares.

In 1913, the mineral rights to these lands belonged to the Prussian Government, but application had been made for concessions of about 5,000 hectares adjacent to the old boundary between French Lorraine and Lorraine Annexée.

Geologic Features.—Coal occurs in the Saar District in the Stephanian and Westphalian series of the Carboniferous system. The beds have been divided as follows by Defline:[9]

Stephanian series (Ottweiler stage)	Upper (sterile).	
	Lower (zone of anthracite and long flame coal).	
	Sterile transition zone.	
Westphalian series (Saarbrück stage)	Beds of long flame coal	Upper
		Lower
	Beds of short flame coal	Upper
		Lower

The metamorphism of the coal measures in the northern part of the basin has rendered the coal anthracitic in character. The southern part of the basin has not been thus affected, and it is there and in the eastern portion of the area that the largest tonnage of coking and gas coals is mined.

The basin is deliminated on the south by an east-west trending fault of considerable displacement, and mining is complicated by numerous NE.–SW. and NW.–SE. trending faults of the fantail type recognized in northeastern France and Belgium. On the west, the coal beds plunge under a heavy cover of younger strata and there the limits will be determined by the depth of profitable mining. The Saar basin contains from twenty-seven to thirty-seven workable coal beds, aggregating 38 to 43 meters in thickness and at depths of 128 to 1,400 meters. The individual beds are all less than 1.5 meters in thickness, and are separated into a number of benches by seams of bone and shale. Table XIII. gives the best information available on the area of the coal lands:

Geographic Distribution.—The coal basin of the Saar covering an area of about six hundred square kilometers has a length of

[9] Defline, M., "Les Ressources de la France en Combustibles Mineraux," Coal Resources of the World, 12th Int. Geol. Congress, 1913, Volume 2, p. 668.

TABLE XIII.

AREA OF SAAR COAL FIELD.

Province.	Area of Known Coal Lands (Hectares).	Area of Possible Coal Lands (Hectares).
Rheinland (Saar District)	100,000	——
Bavarian Palatinate	5,000	40,000
Lorraine Annexé	30,000	60,000
Total	135,000	100,000

sixty-eight kilometers between Frankenholz and St. Wendel in a northeast-southwest direction, and a transverse width of twenty-eight kilometers between Dillingen and Saarbrück. (See Fig. 35.) Quoting Schlichter[10]

the basin is divided into east, west, and middle regions, all producing principally short-flame (coking) coal; his figures, rearranged for the purpose, are as follows:

TABLE XIV.

BASIN OF THE SAAR.

Region.	Location of Area.	No.[11] of Veins.	Thickness of Coal Veins (Meters).		Average Depth of Mining (Meters).	Kind of Coal Produced.
			Ave.	Max.		
West Fields.....	Falkenberg region ..	32	1.33	1.41	829	Short-flame
Central Fields ..	Volklingen region..	37	1.16	1.25	681	Short-flame
East Fields.....	St. Wendel region .	27	1.40	1.52	510	Short-flame

Classification of Coal.—Coal mined in the Saar basin has received the following commercial designations: *magerkohle,* which is equivalent to the long-flame coal of the French and to the flénus secs of the Belgians (V. M. content, 33–45 per cent.); and *flammkohle* and *fettkohle,* which are the same as the short-flame coal of France and the flénus gras of Belgium (V. M. content, 20–33 per cent.). This classification differs considerably from that of the Westphalian District as will be noted later. Based on their chemical composition and calorific value, coal in western Germany is classified as follows:[12]

[10] *Zeit. für das Berg-, Hütten-, und Salinenwesen,* 1910, Band II., p. 356.
[11] Twenty mines in operation in 1913.
[12] Gruner and Bousquet (see Bibliography).

TABLE XV.

CLASSIFICATION OF COAL OF WESTERN GERMANY.

	Saar Coal Basin.				Aachen Coal Basin.							
	Westphalian Coal Basin.											
	Long Flame Coal.				Short Flame Coal.		Semi-bituminous Coal.		Anthracite.			
	Flammkohle.			Gazkohle.		Fettkohle.		Magerkohle.		Anthrazit.		
Composition C..	74	76	78	80	82	84	86	88	90	92	94	96	97
Composition H..	5	5	5	5	5	5	5	5	5	4	3	2	1
Composition O..	21	19	19	15	13	11	9	7	5	4	3	2	1
Calorific value....	6800	7100	7400	7600	7800	8000	8300	8500	8800	8700	8500	8400	8200
Vaporization.....	8.4	8.4	8.7	9.0	9.2	9.4	9.8	10.0	10.4	10.2	10.0	9.9	9.6
Coke (yield).....	50	53	55	60	63	65	70	75	78	80	90	95	98
Volatile matter content (per cent.).....	37–45				33–37		20–33		5–20		less than 5		

Labor.—In 1913, 70,215 men were employed in the Saar coal mines, of whom thirty per cent. were foreigners. The average annual production per individual in 1913 was 242 tons; that for the government mines being 228 tons, and that for the private mines 260 tons per employee. Table XVI. shows in a measure the inefficiency in operation of the government mines:

TABLE XVI.

COST, AVERAGE SELLING PRICE AND PROFIT PER TON OF COAL.

Per Metric Ton.	1904–1912.				1913.			
	Government Mines.		Private Mines.		Government Mines.		Private Mines.	
	Marks.	Aver. Selling Price (%).	Marks.	Aver. Selling Price (%).	Marks.	Aver. Selling Price (%).	Marks.	Aver. Selling Price (%).
Total cost.....	10.80	90.60	9.24	77.73	10.35	85.85	10.07	83.55
Average selling price at mine.....	11.91	100.00	11.91	100.00	12.07	100.00	12.07	100.00
Profit.....	1.11	9.40	2.67	22.27	1.72	14.15	2.00	16.43

Production of Coal.—The manner in which statistics on production, etc., are compiled makes research difficult for data on the coal basins as units. In the table which follows, the Saar District is understood to include a portion of the Bavarian Palati-

nate, Alsace-Lorraine, the Bavarian inspection district of Zweibrücken and the grand duchy of Baden, but not the Oberbergamtbezirk Bonn in its entirety. The steady increase in production from 1904 to 1913 is due not only to increased output of the state mines, but to extensive developments and the introduction of modern mining methods by the private mines. It has long been recognized in Germany that the government mines were less efficiently operated than those in private hands. Evidence of this is found in the reported cost of production. As shown in Table XVI. the average cost of coal mined for the year 1913 was 10.35 marks per ton for the government mines and 10.07 marks per ton for the private mines, the corresponding profits being 1.72 marks per ton in the former instance and 2.00 marks in the latter. This is assuming that the private operators sold their coal at the same price as did the government, which is not always correct, for some of the former undersold the latter. It should be noted, however, that these profits are much higher than those of the French and Belgian coal mines.

TABLE XVII.

SAAR COAL MINES AND THEIR PRODUCTION (METRIC TONS).

	1904.	1910.	1913.
No. active mines	19	20	20
Aver. Am. Prod. per employee	218	200	242
Production of state mines	10,363,700	10,823,500	13,006,200
Production private mines (calculated)	2,488,800	3,589,500	3,994,400
Per cent. of total product (calculated)	19.35	24.90	23.54
Total production	12,852,500	14,413,000	17,000,600
Average selling price per ton (marks)	11.46	12.20	12.07

Imports and Exports.—Since the Saar District consumes only about fifty-seven per cent. of the coal it produces, it is a natural export province. The imports are relatively small and are in the nature of coking coal and coke from the nearby Westphalian coal fields. These imports are made necessary because of the fact that it has been found impracticable to smelt Lorraine iron ore with Saar coke unless the coke is mixed with about twenty per

cent. of Westphalian, or equally good coke. Taken alone, Saar coke has been found to have about sixty-seven per cent. the efficiency of Westphalian coke.

Of the exports to France, nearly the entire amount is delivered to blast furnaces in the Briey-Longwy iron ore district. In the compilation of exports (Table XVIII.) the exports to "Other Countries" are almost entirely to Switzerland and Italy.

TABLE XVIII.

SOURCES OF COAL CONSUMED IN SAAR DISTRICT (METRIC TONS).

	1904.	1910.	1913.
Total Saar production	12,852,500	14,413,000	17,000,600
Imports from Westphalia	588,200	705,500	810,900
Exports to France	98,100	149,200	794,000
" " Belgium	628,000	376,000 E.	134,000
" " Germany	1,348,000	3,587,000 E.	6,326,000
" " Other countries	38,000	727,000	900,000
Total exports	2,012,000	4,839,200	8,154,000
Total consumption of Saar	8,580,300	10,279,300	9,657,500

E—estimated.

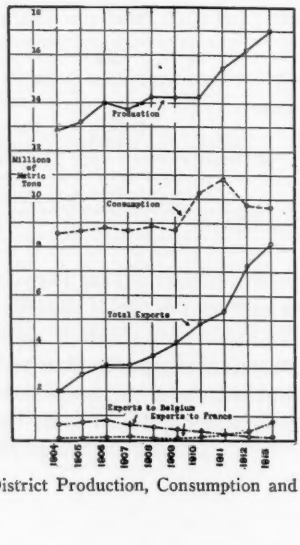

FIG. 39. Saar District Production, Consumption and Exports of Coal.

A diagrammatic representation of the coal production, consumption, and exports of the Saar District is shown in Fig. 39.

Reserves.—The estimates of Böker given at the Twelfth International Geological Congress are the only ones at hand. It is thought that, if anything, these approximations are too low. The area has been well defined by drilling, and the principal actual reserves have been located in the east half of the basin. The effect of the control of these reserves by France has already been mentioned; for, from a fifth-rate power as regards coal reserves, she advances to a position of third in Europe following Germany. The tabulation of reserves which follows shows that fifty-eight per cent. of the actual reserves of cokable coal are above a depth of 1,200 meters, as are also fifty-nine per cent. of the total actual reserves.

TABLE XIX.

ACTUAL COAL RESERVES OF THE SAAR DISTRICT, 1913 (METRIC TONS).

	Cokable Coal.	Total Coal.
Between 0 and 1,200 meters.....	9,042,000,000	9,760,000,000
Between 0 and 2,000 meters.....	15,605,000,000	16,548,000,000

Commercial Use of Coal.—The principal use of Saar coal aside from strictly domestic consumption and export to Germany, is in its use in the metallurgical industry both in the Saar District and in the adjacent Briey-Longwy iron-ore field.

The coking coal of the Saar District is of an inferior quality compared to that of the French, Belgian, and Westphalian fields with which it comes in competition. Its most direct competitor is the Westphalian coal which yields about seventy-eight per cent. coke against about fifty-two per cent. for the Saar field. It has been found that the Saar coke is not strong enough for blast furnace use. The best coking practice in the Saar District provides for an admixture of twenty per cent. of Westphalian coking coal in the coke ovens. For furnace charges one hundred fifty tons of Westphalian coke are considered the equal of one hundred eighty tons of Saar coke. Reducing these factors indicates that Saar coking coal for furnace use is sixty-seven per cent. of the value of Westphalian coking coal. In blast furnace practice, it is

customary when conditions permit to make the charge of equal quantities of Saar and Westphalian coke.

Had the Saar coal not been in competition with the better fuel from Westphalia, the field would have undoubtedly been more extensively developed. In this competitive trade, the Saar coal finds its best use for steam, gas, and domestic purposes.

Of the seventeen coking plants in the Saar District, ten belong to the Prussian Government, one to a French Company, and six to German corporations.

Conclusion.—It has been shown that the estimates of actual reserves of coal in the Saar District will probably be increased by exploratory work in the western portion of the basin; that, with efficient operation, the government mines can be expected to increase their production at diminished cost; and that France cannot rely on coking coal from the district to supply that formerly imported from Westphalia, because of its inferior character for metallurgical work.

An estimate of the value of German interests in Saar coal lands, mines, and coking plants is given in Table XX. In this estimate

TABLE XX.

ESTIMATED VALUE OF GERMAN INTERESTS IN SAAR COAL LANDS, COAL MINES, AND COKING PLANTS, 1913.

Prussian Government:		
Coal lands	120,000,000 francs	
Coal mines and equipment	160,000,000 francs	
Coke plants	20,000,000 francs	
Total		300,000,000 francs
Bavarian Government:		
Coal lands	5,000,000 francs	
Coal mines and equipment	6,000,000 francs	
Total		11,000,000 francs
Private Coal and Coke Companies:		
Coal lands	50,000,000 francs	
Coal mines and equipment	44,000,000 francs	
Coke plants	36,000,000 francs	
Total	130,000,000 francs	
Less French interests	30,000,000 francs	
Total		100,000,000 francs
Grand total		411,000,000 francs

coal lands were evaluated at 1,200 francs per hectare, mines at 12 francs per annual ton of production, and coke ovens at 30,000 francs each; the figures being obtained from the best information at hand.

THE COAL INDUSTRY OF WESTPHALIA.

General.—The coal fields of the Westphalia District are the largest and most productive in Germany and contain about 75 per cent. of the total German reserves.

There are included in the district two distinct basins. The Westphalia basin proper lying east of the Rhine with its western extension, the North Krefeld basin, and the discontinuous basin of Brüggen-Erkelenz and Würm-Inde areas. Of these two basins, that lying east of the Rhine produces the greater proportion of coal mined in the district. (See Fig. 35.)

Geologic Features.—The coal basin of the Ruhr offers the greatest analogy with the Franco-Belgian fields. Coal occurs in the same geologic horizon, its lower part composed of a succession of thick sterile sandstones which give place to a succession of coal beds in which one observes a like enrichment in volatile matter in an upward direction. Diastrophic movements, which resulted in the crumpling of the Franco-Belgian coal measures against the Ardennes massif, likewise crushed the beds on the west side of the Rhine against the Eifel, and those east of the Rhine against the granite to the south. The latter are folded in parallel plications under the action of this lateral pressure, the folding being more accentuated in the southern part of the basin where minor plications are numerous and steep than in the northern part where the folds are broad and deep. Normal faulting is prominent, radiating to the northeast and southwest. A large thrust fault delimits the southern boundary of the basin.

Geographic Distribution.—The Westphalian coal district or the Basin of the Ruhr occupies an area of not more than three thousand square kilometers on the right bank of the Rhine, extending in an easterly direction from Duisberg to Hamm, a distance of about one hundred and forty kilometers, and has a width in the vicinity of Dortmund of about fifty-five kilometers.

The Brüggen-Erkelenz coal basin lies to the west of the Rhine and extends in a southerly direction from the Holland frontier to a little beyond Erkelenz, having a length of about twenty kilometers and a width of about eight kilometers. It crosses the Meuse River west of Venlo and is known in Holland as the non-conceded Basin of the Peel.

The North Krefeld coal basin is the westward continuation of the Basin of the Ruhr, and extends west from the Rhine to the Holland frontier. Its length in a north-south direction is about thirty-six kilometers and its width from east to west is about thirty kilometers.

The Würm-Inde coal district has for its center Aix-la-Chapelle (Aachen). It continues into Belgium as the Campine Basin. From just west of Düren to the Belgian frontier it has a width of twenty-seven kilometers, and in a north-south direction a length of forty kilometers.

In general, the various kinds of coal mined in the Basin of the Ruhr are distributed as follows:

Coal.	Depth, Meters.	Part of Basin.	Thickness, Meters.
Gasflammenkohle	335	———	± 7
Gaskohle	720	———	± 22
Fettkohle	568	West	± 23½
Fettkohle	709	Central	± 28
Fettkohle	885	East	± 36
Fettkohle	600	North	± 19½
Magerkohle	1175	———	± 10

Data on the number of mines, thickness of the coal mined, and kind of coal are given for each of the above basins of the Westphalian District in Table XXI.

Classification of Coal.—In Westphalia, coal is classified commercially as follows:

Flammkohle which corresponds to the long-flame coal of France;
Gazkohle which corresponds to the short-flame coal of France;
Fettkohle which corresponds in part to both short-flame and semi-bituminous coal of France;
Magerkohle which corresponds to the semi-bituminous coal of France; and
Anthrazit which corresponds to the anthracite coal of France.

TABLE XXI.

WESTPHALIAN COAL MINES, AND KIND OF COAL PRODUCED, 1913.

Region.	Location of Area.	Mines in Operation.	No. of Coal Veins.	Thickness Coal (Meters).		Ave. Depth Mining (Meters).	Kind of Coal.
				Ave.	Max.		
Ruhr....	East of Rhine. Essen as a center	173	136	0.80	1.0	698	Long-flame, short-flame, semi-bitum.
Aachen ..	East, South and North of Aachen	12	36	0.40	1.6	1,000	Long-flame, short-flame, and semi-bitum.
Würm-Inde							
Brüggen-Erkelenz	West of Dusseldorf, left bank of Rhine	14	40	0.40	2.0	700	Long-flame, semi-bitum. and semi-anthr.
Nord-Krefeld	Left bank of Rhine. North of Krefeld.	22	49	0.94	1.2	1,000	Long-flame, short-flame, and semi-bitum.

A classification on the basis of calorific value has been given in the article on the Saar District on page 298.

Labor.—In 1913, 392,100 men were employed in the mines of the Westphalian coal district, of whom about twenty-five per cent. were foreign laborers. The average annual production per individual for that year was 299 metric tons; that for the syndicate mines being 300 tons, and that for the non-syndicate mines 295 metric tons per employee per year. The average annual salary per employee for both syndicate and non-syndicate mines was, in 1913, 1,714 marks, or 5.71 marks per day for three hundred working days.

Cost of Mining and Profits.—Unfortunately no statistics are available which would enable a separation to be made between the earnings of mines adherent to the Westphalian Coal Syndicate and those that are non-syndicate. However, it is fairly certain that the profits of the former exceeded the latter, since the Syndicate virtually controlled the fuel supply of the blast furnaces and steel plants, thus being able to dictate prices. By agree-

ment with the Stahlswerkverband which controls the iron and steel industry, a fixed price was named for a given annual tonnage of coal, the Syndicate being at liberty to name its own price per ton for all additional amounts supplied. In 1911, this agreement was broken with the result in 1912 that the price of coal advanced 1.68 marks over the 1911 price and showed an additional increase in 1913 of 0.60 marks over the 1912 price. Table XXII. shows that even with this increase the profits per ton of coal in 1913 were less than the average profit for the nine preceding years.

COST, AVERAGE SELLING PRICE, AND PROFIT PER TON OF COAL.

Per Metric Ton.	1904–1912.		1913.	
	Marks.	Average Selling Price (%).	Marks.	Average Selling Price (%).
Total cost	8.16	85.57	10.66	88.66
Average selling price at mine	9.54	100.00	12.02	100.00
Profit	1.38	14.43	1.36	11.34

Production of Coal.—In this paper the Westphalian District is understood to include the coal Basin of the Ruhr, the North Krefeld basin, the Brüggen-Erkelenz basin, and the Würm-Inde district, otherwise known as the Aachen or Aix-la-Chapelle district. The statistics on the Basin of the Ruhr include the Niederheinischer-Westfälischer commercial district and the Schaftberg-Piesberg districts, also a portion of the Oberbergamtsbezirk Dortmund.

The total coal production of Prussia, in which all of these coal basins lie, was, in 1913, 181,413,000 metric tons; that of all Germany was 191,511,000 metric tons. Of the total Prussian production, 64 per cent. was produced by the Westphalian District, as was 62 per cent. of the total German production.

With the exception of the North Krefeld basin no data on the production of the small basins has been found. This basin produced 3,700,000 metric tons of coal in 1913.

The enormous increase in production of 21,334,800 metric tons for the Westphalian District as a whole between the years of

1911 and 1913, is thought to be due not only to the opening up of eleven new mines, but to the more intensive and efficient mining methods adopted by the older mines.

A tabulation of data on the coal mines of the Westphalian District and their production for the decade 1904–1913 is given in Table XXIII.

TABLE XXIII.

COAL MINES OF WESTPHALIA AND THEIR PRODUCTIVITY (METRIC TONS).

	1904.	1910.	1913.
No. of mines	160	169	185
Ann. prod. per employee	248	250	299
Prod. of Syndicate Mines	67,255,000	83,628,000	101,652,000
% of total production	95.00	91.10	86.50
Prod. Non-Syn. Mines	3,489,000	8,116,500	15,795,300
% of total production	5.00	8.90	13.50
Total production[15]	70,744,000	91,844,500	117,447,300
Aver. selling price per ton (marks)	8.25	9.79	12.02

Imports and Exports.—Of the total coal mined in Westphalia in 1913, 27 per cent. was exported to foreign countries and to other parts of Germany. This figure includes coke as well as coal. The realtively large local consumption is necessitated by the demands of the metallurgical and manufacturing industries located at Essen, Ruhrort, Duisberg, Dortmund, and Hamm, which consume annually about 4,500,000 tons of Lorraine iron ore.

Extensive canalization of rivers in Germany and to the west has lowered freight rates as well as made accessible large inland manufacturing towns; and that, together with the navigable Rhine giving egress to the English Channel, has made the Westphalian coal fields of unrivaled importance in Europe.

A tabulation of exports during the period 1904 to 1913 is given in Table XXIV.

This tabulation for years 1904–1913 is graphically shown in Fig. 40.

[14] Total production of all mines in the Ruhr, Krefeld, Brüggen-Erkelenz, and Aachen Basins, including Syndicate and Non-Syndicate Mines.

Reserves.—The estimates of Kukuk and Mintrop given before the Twelfth International Geological Congress in 1913 are the

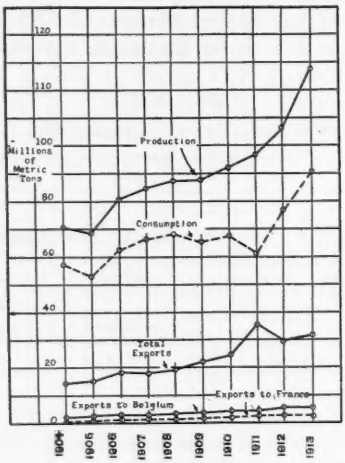

FIG. 40. Westphalian Production, Consumption and Exports of Coal.

TABLE XXIV.

COAL PRODUCTION, CONSUMPTION, AND EXPORTS OF WESTPHALIA (METRIC TONS).

	1904.	1910.	1913.
Total production	70,774,000	91,884,500	117,447,300
Exports to France	663,000	2,007,800	2,688,000
" " Belgium	2,311,000	4,213,900	5,728,000
" " Germany	7,619,000	11,925,000	15,603,000
" " Other countries	3,800,000	6,214,000	7,749,000
Total exports	14,393,000	24,360,700	31,768,000
Total consumption	56,381,000	67,438,800E.	85,679,300E.

E—estimated.

only ones at hand; they are given in a rearranged form in the table below. Exploratory work by drilling in the north, east, and west portions of the basin will serve to delimitate it and at

the same time give more accurate knowledge as to the actual coal reserves. The southern border only has been definitely fixed as to the depth at which mining can at present be conducted at a profit.

Exclusive of the Saar District it is known that 85 per cent. of the total actual reserves of cokable coal in Germany lie in the Basin of the Ruhr, and that 72 per cent. of the total actual reserves of all kinds of coal, eliminating the Saar District, likewise occur there.

TABLE XXV.

THE ACTUAL COAL RESERVES OF WESTPHALIA, 1913 (METRIC TONS).

	Between 0 and 1,200 Meters.		Between 0 and 2,000 Meters.	
	Cokable Coal.	Total Coal.	Cokable Coal.	Total Coal
Right bank of Rhine:				
Westphalia.....	26,373,000,000	39,481,000,000	33,354,000,000	56,344,000,000
Left bank of Rhine:				
Nord-Krefelder .	3,538,000,000	7,100,000,000	3,538,000,000	7,100,000,000
Brüggen-Erkelenz.....	1,732,000,000	1,746,000,000	1,732,000,000	1,746,000,000
Würm-Inde.....	537,000,000	1,612,000,000	537,000,000	1,612,000,000
Total.....	32,180,000,000	61,454,000,000	39,161,000,000	78,317,000,000

Commercial Use of Westphalian Coal.—It is due to the location of the Westphalian District at practically tidewater as well as to the excellent quality of the coal for metallurgical and industrial purposes, that the coal operators of the district have been able to control to such an extent the industry of Germany. Coal from the district is used not only in all parts of Germany but also in western Europe in general. It is this widespread use of the fuel that has enabled the Westphalian Coal Syndicate to control to such an extent the industry as well as the metallurgy of the

The coal is extensively used for coking purposes. Due to refinements in process, the Germans have secured an almost incredibly high recovery of by-products, and it is this efficiency of operation that has enabled them to undersell French and Belgian competitors.

Conclusion.—The foregoing statements and figures present incontrovertible evidence of the dominating position of Westpha-

lian coal in the metallurgical industry of western Europe. France is dependent upon it even with the acquisition of the Saar fields, as is Belgium. The exchange of Lorraine ore for Westphalian coke would probably temporarily solve the problem.

It has been shown, as well, that the district not only produces excellent grades of metallurgical coal in larger quantities than the other countries under consideration, but also more cheaply. In 1913, the total cost of mining represented only 89 per cent. of the selling price, while in France the same relation was 93 per cent., and in Belgium, 96 per cent. The average sale price of Westphalia and Saar coal, in 1913, was 9.64 francs per ton against an average price of 17.44 francs per ton for the same year for France and Belgium.

In other words, German competitors undersell French and Belgian operators 90 per cent., yet make profits 100 per cent. in excess of those of these two countries!

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VEIN FILLING AT BENDIGO, VICTORIA.

WALDEMAR LINDGREN.

The mode of formation of the gold quartz deposits occurring as saddle reefs at Bendigo has recently been discussed in the issues of ECONOMIC GEOLOGY.[1] Mr. Stillwell has shown that to some extent quartz may replace the black shale especially in thin wedges and sheets of the latter, but it may well be doubted whether this process accounts for the predominating vein filling which consists of pure milky white quartz in large, optically undisturbed individuals. On the whole the metasomatic action of the vein-forming solutions on the black slate is very slight, often entirely imperceptible. In places a little pyrite has developed in the country rock and some sections show a little carbonatization of the slate.

It is very common in gold-bearing quartz deposits to find veins or bodies of pure milky quartz lined along their contacts by ankerite. Mr. Stillwell refers to this frequent crustification at Bendigo[2] and my own collection contains several good instances of this structure. One of these specimens is described in the following paragraphs and a photograph of it is reproduced as Pl. X.

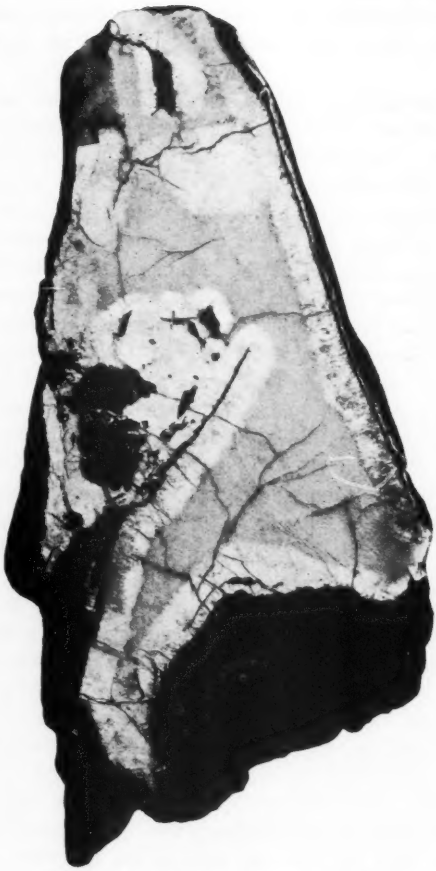
In the same volume of ECONOMIC GEOLOGY Professor Stephen Taber discusses the mode of formation of the Bendigo veins and states his belief that Mr. E. J. Dunn is correct in ascribing the opening of the veins to the pressure of the crystallizing quartz. Mr. Taber admits that the vein forming solutions were of mag-

[1] F. L. Stillwell, "Replacement in the Bendigo Quartz Veins and its Relation to Gold Deposition," ECON. GEOL., Vol. 13, 1918, pp. 100–111.

Alan M. Bateman, "Replacement in the Bendigo Quartz Veins," ECON. GEOL., Vol. 13, 1918, pp. 222–223.

Stephen Taber, "Origin of the Bendigo Quartz Veins," ECON. GEOL., Vol. 13, 1918, pp. 538–546.

[2] *Op. cit.*, p. 102.



Gold-bearing quartz bordered by ankerite.

matic origin and that they were forced into the strata under heavy pressure. The real opening of the veins was, however, according to him caused by the "force of crystallization" of the quartz which thus must have been of a magnitude very much greater than the pressure of the solutions which carried the quartz.

I can not share this opinion and as evidence for my point of view simply present the description referred to. It does not seem to me that the phenomena shown can be accounted for on the theory of any "force of crystallization." However, I may be mistaken and if so should appreciate any better explanation.

The specimen was taken from one of the dumps of the New Chum reef line. The country rock shown dark on the photograph consists of black slate, in places bent and foliated. There is no perceptible alteration or replacement except that it contains a few minute crystals of pyrite which are a little more abundant around the two larger inclusions which appear in the ankerite. The specimen shows an irregular opening in the slate filled with ankerite and quartz. The reverse side of the specimen shows only black slate with a narrow branching vein of the same minerals. The large opening is, therefore, simply an enlargement by the bulging slate lamellæ. The opening is coated by an ankerite crust averaging 5 millimeters in thickness, made up of individuals, 2 to 3 millimeters thick and separated from the quartz by a contact line which in detail is quite irregular. The ankerite, which weathers brown, not only coats the walls but also surrounds several slate inclusions and a long thin sliver of slate. These, however, are not unsupported but connect with the main mass of slate on the reverse side of the specimen. There are also at several places thin slivers of slate separated from the main mass by a thickness of about 1 millimeter of ankerite.

The central mass is milky white quartz penetrated by a few branching cracks. On close examination it is observed that the quartz has corroded the ankerite and that the latter contains a network of veinlets of quartz. A thin section demonstrates at once that the quartz is later than the ankerite, replacing it along

the contact and along the numerous veinlets. Many of these veinlets consist of granular quartz with abundant albite. The main mass of the quartz filling consists of large individuals 10 to 20 millimeters in diameter, showing no crystal outlines and being absolutely free from optical disturbances. The same quartz individual may continue deep into the embayments of the ankerite.

It seems difficult to explain these relations by any other theory than that the cavity in the slate was first formed and that it remained open until the coating of ankerite had been deposited. At that time the character of the solutions changed and quartz was deposited. The large size of the quartz individuals suggests high temperature. Rapid filling is suggested by the only partial replacement of the ankerite. To the action of the "force of crystallization" may fairly be ascribed the splitting off of thin slate slivers from the wall and perhaps also some movement of the inclusions in an open space filled with solution. Such movements may be easily effected by the growing force exerted by the ankerite crystals. My main proposition is that the cavity was there before the quartz was deposited. This, it will be observed, is not admitted on the basis of the theory advanced by Mr. Taber.

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THE CLASSIFICATION OF UNDEVELOPED OIL LAND FOR PURPOSES OF VALUATION.

CARL H. BEAL.

INTRODUCTION.

In valuing oil land during the last few years, the author has found it necessary to adopt a standard for classifying the lands to be valued. Some standard of classification is necessary not only in valuing oil properties, but also for use in publications dealing with the oil resources of individual fields. If a publication or report—public or private—states that there is a certain number of acres of proved oil land in the United States, the adjective "proved" should be so standardized that it will immediately have the same meaning to all.

This need of some uniform classification, especially in the valuation of oil properties, seemed so apparent that the author prepared and sent a circular letter to a number of geologists and petroleum engineers, who probably would be interested, requesting their views on tentative definitions. Many suggestions were received and the definitions herein proposed may be said to be a consensus of opinion rather than the opinion of one person. The author claims no credit except of having combined the ideas of others into usable definitions.

Although ideas and suggestions were gained from numerous conversations with other members of the profession, the following have contributed principally to this paper: I. C. White, state geologist of West Virginia; J. C. Branner, president emeritus, Stanford University; J. O. Lewis, chief petroleum technologist, U. S. Bureau of Mines; R. E. Collom, petroleum technologist, U. S. Bureau of Mines; Roderic Crandall, Chester W. Washburne, A. Beeby Thompson, Roswell Johnson, M. J. Munn, Arthur Eaton, J. H. Gardner, Dorsey Hager and F. G. Clapp, consulting geologists and petroleum engineers; M. L. Fuller, of The Sun

Company; C. R. Eckes, of The Texas Company; E. D. Nolan, of The General Petroleum Corporation; R. C. Conkling, of The Roxana Petroleum Company; G. C. Gester, of The Standard Oil Company of California; and M. E. Lombardi, of the Fuel Oil Department, Southern Pacific Company.

In any classification of undeveloped oil land, the definitions adopted should be comprehensive but simple and, if possible, as easily applicable to the sharply-folded fields in California as to those occurring in the relatively little-disturbed oil-bearing areas of Oklahoma, Kansas and Texas. The classification must be based on definitely ascertainable factors and the definitions adopted must be such that any geologist will experience little difficulty in applying them to undeveloped land in or near any oil field or in an area where the existence of oil is not known.

The scientific classification of lands involves a broad knowledge of the *occurrence* of oil and gas with relation to geologic structure, the stratigraphy of the beds, texture of the sand, the effect of possible lenticularity of sands on accumulations, modes of accumulation, and the importance to attach to the different factors causing oil accumulation and occurrence. Although classifications made by various persons may differ widely because of the divergence in conceptions of the causes of and factors controlling accumulations, this variation should become less and less as the principles of oil accumulation and occurrence become better known. It has been demonstrated that the classification of lands made in an area where no wells have been drilled, may be radically changed by the additional information disclosed by drilling one well. For example, some anticlines in the Mid-Continent field, prior to development, may be classed as possible or probable oil land, whereas they are found to be worthless for oil when drilled.

The most useful classification is one based on the oil possibilities of the land. The oil possibilities of undrilled land must be determined absolutely from surface or underground geologic data, including information on the occurrence of oil in drilled areas which are similar geologically, factors controlling oil accumulation, and other criteria, unless the undrilled land is ad-

jacent to development, when, in some cases, favorable geologic conditions will be of secondary importance. Any classification of undrilled land, especially if made for purposes of valuation, should show essentially the prospects of obtaining oil in commercial quantities. It seems to be the consensus of opinion that three or four easily definable classes should be set up, because of the difficulty of segregating oil land into more classes. One correspondent, however, advocates the adoption of no particular classes, preferring to apply to different areas, with different chances of becoming commercially valuable land, the mathematical probability which expresses this chance. This probability he would express as a percentage of commercially productive land. For example, if the chances are 6 to 10 of a tract of land becoming commercially productive, the probability will be $\frac{6}{10}$ or the percentage will be 60, the percentage expressing the prospect of commercial production.

The author believes it to be practically impossible, however, to gage the factors determining the prospect of production and to express this prospect mathematically. It seems far better to define a few general classes, and to apply percentages in particular cases, when it is possible to do so and the appraiser finds such a procedure necessary.

DEFINITIONS.

General Considerations.—In this paper undeveloped oil land only is under discussion; that is, land which has some prospects of producing oil, but on which no wells have been drilled. No definition is therefore given for worthless land, each class defined possessing some implied value for oil purposes.

Undeveloped land possessing some value for oil purposes may be rather easily divided into (1) proved, (2) probable, (3) possible, and (4) commercially non-productive land, the first three being in the order of the probability of obtaining oil in commercial quantities. A similar tentative classification was given by the writer[1] two years ago, but it is hoped that the present definitions will supersede the others.

[1] Beal, Carl H., "The Decline and Ultimate Production of Oil Wells with Rates on the Valuation of Oil Properties," Bull. U. S. Bureau of Mines No. 177, p. 82, 1919.

The term "prospective" has not been applied to any of these classes. Although its convenience and universal use argue strongly for its definition, the broad latitude of its meaning renders it almost impossible to define. Nearly all undeveloped oil land possessing any prospects of producing oil in commercial quantities is referred to loosely as "prospective" oil land and as the term is so valuable when used in that capacity, no attempt was made to restrict its meaning to a narrower sense. Consequently the term "prospective oil land" is not defined as other than that which possesses prospects of producing oil in commercial quantities and it will thus include in its scope all such land.

Proved Oil Land.—Proved oil land is that which has been shown, by finished wells supplemented by geologic data, to be such that other wells drilled thereon are practically certain to be commercial producers.

This definition has been modified from that given for the California oil fields by McLaughlin.[2] The oil companies in that state, as a general rule, are paying light taxes on proved oil land in accordance with McLaughlin's definition, and although the tax is small, the fact is mentioned to show that a definition similar to the one here proposed has already been accepted by oil operators in one part of the United States.

The modified definition was proposed by the author in a publication of the U. S. Bureau of Mines,[3] and later to the Bureau of Internal Revenue, Treasury Department, in January, 1919, for incorporation by that bureau in the regulations relating to income tax and was given by the Treasury Department[4] for the use of the oil operators.

The basis of the definition is the *practical* certainty of obtaining oil in commercial quantities, and land cannot be placed in the proved class if any doubt exists regarding this practical certainty. The practical certainty is based on the data from wells

[2] McLaughlin, R. P., "Petroleum Industry of California," California State Mining Bureau Bull. 69, p. 13, 1914.

[3] *Op. cit.*, p. 82.

[4] Regulations 45, relating to income tax and war profits and excess profits tax, under the Revenue act of 1918, 1919.

that have already been drilled; geologic data are supplementary or secondary. Information given by the drill is usually final, although observations for the determination of proved acreage should be supplemented by such geologic data as are available. Contiguous producing wells are, therefore, a necessary prerequisite; the author has never found a case where the underground conditions of land not contiguous to producing wells were sufficiently well known to allow its being placed in the proved class under the definition given above.

Possibly some may consider the word "practically" unnecessary, but we can not be absolutely *certain* of obtaining oil from wells drilled on any undeveloped land until the beds have been tested. In our past experience or practice, however, we have found that undeveloped land with the same prospects as contiguous developed land has yielded oil; "practically" means "not theoretical" or in a "practical way," so that the word becomes useful in modifying the definition, lending the slight element of uncertainty to such land that it deserves.

It should be brought out that the wells must be *commercial* producers, that is, the prospects must be such as to justify commercial exploitation. Quantities sufficient to justify commercial exploitation, as defined by the Treasury Department[5] "are deemed to exist when the quantity and quality of oil or gas so recovered from the well are such as to afford a reasonable expectation of at least returning the capital invested in such well through the sale of the oil or gas, or both to be derived therefrom."

The number of wells necessary to prove an area will vary with the conditions. With a well-defined structure and well-known sand conditions, three or four wells may prove up a large area, whereas if the sand is irregular and the structure certain or if the sand is known to be uniform and the structure of the oil sand uncertain, much of the area would be placed in the probable class until more wells were drilled. Land can not be proved—that is, fairly certain to support commercial producers—unless the sand is known to be fairly uniform.

[5] T. D., with Regulations 45, approved Dec. 2, 1919.

In delineating proved oil land on a map, one is guided principally by finished wells, but the underground geologic conditions must also be carefully studied and used as a further guide. The character of the geologic structure is the usual criterion in which much trust is placed, but in some fields the underground geologic structure possesses minor significance, the more important factors being the difference in porosity of the beds, the lenticular character of the sands, both locally and regionally, and the water conditions in the sand. These factors may act singly or in any combination, closely interprelated and of equal or unequal importance. A person must possess a thorough knowledge of the principles governing oil accumulation before he can intelligently delineate proved oil land. The Kern River field in California and the Glenn Pool in Oklahoma are notable examples of accumulations which owe their existence to factors other than geologic structure. In general, both are monoclinal in character.

The factors governing oil accumulation may vary greatly in different fields. In some localities, such as in California and Wyoming, geologic structure may be the principal factor and because of this, the main outline of proved land will be determined by the locations of producing wells, and the undrilled areas between producing wells will be classified by structure. For instance, the proved acreage, including the drilled land, may be rather easily determined by drawing a line enclosing the producing wells, but where undrilled areas occur, the structure of the oil sand is used as a guide (Fig. 41). The distance from the wells of the line bounding proved acerage will depend on conditions. In California in localities where the line is determined by development, it is drawn one location from producing wells.

In some Oklahoma fields, geologic structure apparently plays relatively an unimportant rôle, the accumulations being governed by lenticularity and differences in porosity or texture of the oil sands. An 80-acre tract may have excellent oil wells drilled in its corners, but its central half may be of absolutely no worth when drilled. Several tracts, with which the author is familiar, have been even more misleading. In other parts of the same state, oil is found in synclines.

Where geologic structure is not the controlling factor it is unwise to draw the limits of proved acreage a great distance from producing wells, because knowledge of the other factors is more

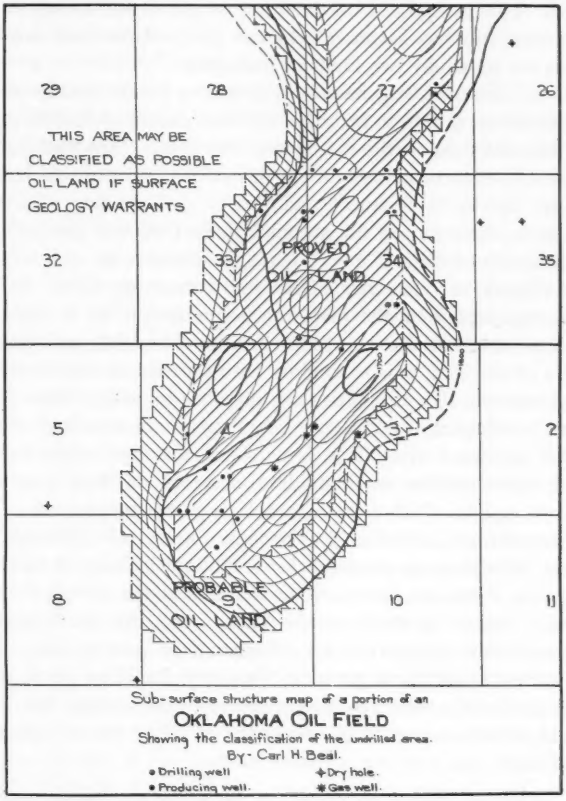

FIG. 41.

difficult to obtain previous to drilling and predictions based on it are thus rendered extremely uncertain.

Figure 41 represents the sub-surface structure of an oil sand in

a portion of an Oklahoma oil field. The structure contours show depths below sea level of the top of the sand and the symbols represent the wells at that time producing oil from the contoured sand. The land proved to contain oil or gas is that on top of the structure with no hachures whereas the probable and possible lands are shown by two kinds of hachures.

It will be noted that the proved area does not lie exactly on top of the structure and, in fact, that all three classes of land lie more on the west than on the east side of the fold. This distribution is entirely in accordance with our definitions. The proved land is limited first by development, and next by geologic data, which includes information on the accumulation of oil and gas and the relationship of oil and gas to geologic structure as well as specific data on the character of the fold containing them. In the area represented by the map, the accumulation, as a rule, lay farther down on the west side or north-side folds and farther down on the long axis of folding than on the east side or short axis, respectively. Furthermore, the beds in which these folds occur in this part of Oklahoma were in general monoclinal with a gentle westward dip. This gives short east dips which do not favor accumulations on that side of the fold and long west dips between uplifts which were favorable as gathering grounds.

Proved Land as Defined by the U. S. Treasury.—Although the above definition was proposed for use by the Bureau of Internal Revenue, it became necessary, on account of the so-called "discovery" clause in the Revenue Act of 1918, for the Treasury Department to put into effect a definition even more specific. The following definition is given in Treasury Decision 2956; it is used by the department in determination of the acreage that may be valued on account of the discovery of oil or gas on undeveloped land.

> . . . A proven area for the purpose of this statute shall be presumed to be that portion of the productive sand or zone or reservoir included in a square surface area of 160 acres having as its center the mouth of a well producing oil or gas in commercial quantities.

The above definition appears to set up 160 acres arbitrarily as

the amount of land proved when a new well is brought in, and although we should not condemn any attempt of the Government to afford the oil operator an easy means of determining quickly the lands for which he may claim a valuation, the faults in the above definition, especially from a geological standpoint, are too obvious to require discussion.

Probable Oil Land.—Probable oil land is that, usually adjacent to producing oil wells, from which the projection of underground geologic data, by a preponderance of evidence, indicates the existence of oil in commercial quantities, but leaves some room for doubt.

"Probable" is defined by Webster is "having more evidence for than against; supported by evidence that inclines the mind to believe, but leaves some room for doubt; likely"; so that if there is more evidence *for* than *against* obtaining oil in commercial quantities, the land should be placed in the probable class—regardless of its location.

The basis of the definition is two-fold: (1) The inference as to the existence of oil, gained from surface geologic evidence supported by the projection of underground geologic data from an area of known conditions, and (2) the contiguity of the land to productive acreage.

Obviously, this definition depends more upon the examination and balancing of all geologic evidence for and against the existence of oil than does the definition of proved oil land.

The nearness to producing wells is relative; it may possess greater importance in some fields than in others. For instance, in a closely folded region of anticlinal accumulations, land which is two locations from a producing well may be worthless, whereas, in a region of gentle dips with oil accumulations rather consistently occurring in the crests of broad domes and anticlines, land, a mile from the discovery well, may easily be placed in the probable class.

Contiguity to production is, therefore, not the controlling factor, for under some circumstances lands may be "probable" that are located a considerable distance from production. For

instance, suppose an oil horizon, known invariably to produce oil wherever encountered under favorable conditions of structure, is determined to lie within reach of the drill, under a favorable structure along the crest of which many seepages occur, but situated several miles from the nearest production. Under these exceptional conditions one would be justified in placing some of the acreage in the probable class, for there seems to be more evidence for than against the existence of oil.

Other examples of probable oil lands are those situated on a well-outlined structure, with regular sands, but not having the limits of production defined, those on good structure with several producing wells, but with more or less irregular sands, and those practically surrounded by producing wells with known irregular sands and where structural conditions may or may not be known (Fig. 41).

Possible Oil Land.— Possible oil land is that, uusually not adjacent to producing oil wells, which, according to geologic and other natural evidence, such as seepages, may produce oil.

The word "possible" seems too broad, for almost any untested land may *possibly* produce oil; "prospective" is the term originally employed by the author, but several correspondents have suggested the substitution, and because these definitions are the result of the deliberations of several men—not one—the term "possible" is being suggested.

"Possible" according to Webster is that which is "not contrary to the nature of things; free to happen or not. That may be true so far as knowledge tells; more or less likely from the circumstances known"; and "prospective" is defined as "being within consideration, as a future contingency; relating to the future; expected."

Possible areas include those not proved and not probable upon which there is any likelihood of obtaining oil in commercial quantities (Fig. 41). Some may argue that this class, therefore, embraces too wide a range of possibilities, and that its range of possibilities or prospects is greater than the range of possibilities of probable land. That is not true, however, if the definitions are

literally limited according to Webster's definitions and modified by our own restrictions; proved oil land is certain for all practical purposes; probable oil land begins with that on which the chances are greater for commercial production than against, and possible oil land ranges from that which has practically no chance to that with an even chance of producing oil in commercial quantities.

The essence of the definition is the distance of the land from production and the fact that the only geoloigc evidence available for consideration is that furnished by surface indications. Synclines in some regions may be rated as possible; "spotted" fields will contain much possible land; in fact, any area, where a majority of chances are against the existence of oil, but where some prospects for oil are found, may be called possible.

Possible and probable oil land is further distinguished from proved land by the lack of a basis for estimating their future production. In the first place, there is no practical certainty that lands in either of these classes will produce oil, whereas, there is a practical certainty that proved land will produce oil. Furthermore, a basis of estimating how much it will produce consists in the records of nearby wells. No such basis exists for the estimation of the future production of possible oil land; assumptions only can be made on the basis of the land's becoming productive.

Commercially Non-productive Oil Land.—Commercially non-productive oil land is that on which commercially productive wells can not be drilled at present.

In many fields this definition will not be used extensively, but in such fields as those in California, there are many areas where the presence of oil is practically proved, but the wells are so expensive that they can not at present be drilled with profit. Probable and possible oil land may also be rated as commercially non-productive, contingent, of course, on the final proof that oil exists there. No land can be placed in this and in any of the other classes at the same time, for if land is proved it will support commercial producers. If the existence of oil is proved but wells can not be drilled with profit, the land, according to our definition, can not be placed in the proved class.

The same argument applies to the other two classes, which are differentiated by their prospects of obtaining oil in commercial quantities. If the existence of oil is probable under a tract of land, and the sand is beyond the reach of the drill, the land must be commercially non-productive.

CONCLUSION.

Land can be classified into the proposed classes usually without great difficulty, and if the boundary lines of different areas are made according to legal subdivisions, the amount of acreage can be readily computed.

Exceptions undoubtedly will be found, and some cases will be very difficult to settle. For instance, in some places the existence of productive zones or sands below a producing sand may be probable or possible. Different areas may be placed in all four different classes, for some of it may be proved and some may be probable, possible, or commercially non-productive. Each sand, therefore, may require a different classification; they must be considered as separate tracts or fields.

The drilling of a gas well on an anticline or dome may cause a difference of opinion as to the oil prospects of the land, and an analysis of the gas may lead one to believe in the existence of oil on the flanks of the fold, whereas, another, without the analysis, would claim that no oil existed in the reservoir. Most of these cases, however, may be settled by a close study of conditions, based on a comprehensive knowledge of oil accumulation, origin and movement.

Land may change rapidly from one class to another. The drilling of one well may prove an extensive area that previously was probable or possible, or it may serve to place commercially non-productive oil land in the proved class. Water troubles may develop, suddenly causing proved areas to lose much of their value and place them in the probable class, or the price of oil may increase to such an extent that wells may be drilled with profit on land where the existence of oil was previously certain, but

which was unprofitable to drill. Known oil-bearing sands, lying below the depth of the drill, and thus commercially non-productive, with improved drilling methods, may later be drilled with profit. In fact, any development that brings forth more evidence may change the classification greatly.

523 WELLS FARGO BLDG.,
SAN FRANCISCO, CAL.

THE DEVELOPMENT OF IRON ORE IN GREAT BRITAIN DURING THE WAR.

F. H. Hatch.

INTRODUCTION.

During 1917 and 1918 the writer was engaged officially with others in the iron and steel department of the Ministry of Munitions on a study of the iron-ore deposits of the United Kingdom.

The progress of the war had, by the end of 1916, produced a serious position in the iron and steel trade: the working stocks of hematite ore were much depleted and at some iron work had practically disappeared, with the result that furnaces were entirely dependent on the arrival of shipments, and several had to be put out of blast.

To meet this position it was decided to increase the production of iron-ore in the United Kingdom. Sir John Hunter, director of iron and steel production, acting under the instructions of the Minister of Munitions, obtained the services of a number of mining engineers and of experts versed in the different branches of the iron and steel industry with whom he formed sections of the iron and steel department to deal respectively with the mining and quarrying of iron-ore and limestone, with the supply of fuel, refractory materials and labor, and with the reorganization of both blast-furnaces and steel furnaces.

In the early part of 1917, a comprehensive survey of the iron-ore resources of the United Kingdom was undertaken and I propose in this article to show how the home production of iron-ore was by the end of the year 1917 increased by a million and a half tons, and during the first part of 1918 by an amount equivalent to 2⅓ million tons per annum.

History.—The first historical reference to Great Britain mentions the export of tin from Cornwall. Also, this country's production and export of copper in the early part of the nineteenth

century were the largest in the world; but for its modern industrial preëminence it is indebted to its coal and ironstone and particularly to the fact that these materials are in part so closely associated in nature that for a time the factor of transportation was practically eliminated. But the gradual exhaustion of the richer blackbands and clay-ironstones of the Carboniferous formation, and the introduction of the acid Bessemer process of steel manufacture, which requires a pure ore free from phosphorus and sulphur, made it necessary to find other sources of iron-ore supply. For many years the United Kingdom has been dependent, for 30 per cent. of the iron-ore used in its blast-furnaces, on foreign countries. Foreign ore plays even a bigger rôle than at first appears, since its average iron content is 50 per cent. as against 30 per cent. for home ores. The importation of hematite, rich in iron and low in phosphorus, from Spain and the Mediterranean, built up the big iron industries now engaged in the manufacture of steel by the acid process in South Wales, on the northwest coast, on the northeast coast, and in Scotland, where the ports of Cardiff, Port Talbot, Whitehaven, Barrow, Middlesbrough, Newcastle and the Clyde, situated in close proximity to an ample supply of labor, enable foreign ore and native coal to be easily assembled and cheaply handled.

Cheap water-transport is the basis of this successful importation of foreign ore; but it was found to have its drawbacks when the war broke out; and the scarcity of ship-tonnage raised the cost of imported ore from about 20s. ($4.86) (at which best Bilbao ore ruled in British ports in 1914) to an actual price of over £6 ($29.15) per ton, although, under the cloak of government subsidies, it figured at a lower level. At one period of the war the supply from these sources threatened to be cut off altogether.

To meet this situation an increased development of the Jurassic ironstones was decided on. These ironstones, although abundant and cheaply worked, are what the ironmasters term "lean," that is to say they are low in iron, averaging only 28 per cent. of that metal. Moreover, they have a high phosphorus and sulphur-con-

tent and, for the most part, are rather siliceous. The large increase in the production of phosphoric ores was reflected in the increased output of basic steel.

PROBLEMS OF INCREASED PRODUCTION.

This increased production raised many difficult problems. In the first place it necessitated a different metallurgical treatment, involving the substitution of basic-lined steel furnaces for those of the acid type, with consequent increased supplies of suitable refractory materials. Further, it involved large additional supplies of fuel for smelting and of limestone for fluxing the ore in the blast-furnaces. Difficulties also arose with regard to the supply of magnesite and magnesite bricks. Prior to the outbreak of war the magnesite brick industry was almost wholly in the hands of the Austrians. The Austrians possess in their own country extensive deposits of magnesite peculiarly suited for brick-making. Having devoted both skill and money to the perfecting of their products they commanded, prior to the war, practically the entire custom of the steel trade of this country. To make up for the loss of this Austrian material, arrangements were made by the Ministry of Munitions for the manufacture in this country of magnesite bricks, and the raw material was obtained from Euboea in Greece and from Salem in Madras. To furnish the required dolomite and limestone new quarries were opened up in this country.

A new supply of labor had to be found not only to work the new quarries of ironstone, limestone, and dolomite, but also to build railways required to open them up, and to erect installations, and this in face of the incessant and urgent calls of the Army to fill the gaps in the fighting line. The lack of quarrymen led to active steps being taken in responsible quarters to supplement and to increase the efficiency of manual labor at the quarries by the provision of mechanical appliances for stripping, breaking and loading the ironstone. In these open workings, the output per man employed varies with the thickness of the ironstone bed, the amount of cover to be removed, the use made of mechanical ap-

pliances, and the condition of the weather. The weather materially affects the output, especially where hand-labor is concerned. From returns made to the Ministry of Munitions in December, 1917, it appears that the average output in the Midlands per man employed was 5 tons per shift, and that it ranged from 3.8 tons, where hand-labor was alone employed, to over 15 tons where mechanical excavators were in use under favorable conditions. The actual saving of manual labor which resulted from the installation of mechanical plant in the ironstone quarries during the war is estimated to have been equivalent to over 3,000 men.

DISTRIBUTION OF JURASSIC ORES.

The Jurassic ironstones have a wide distribution both in the United Kingdom and on the continent. In 1913 Germany mined, in Lorraine and Luxemburg, 28 million tons of minette ores of Jurassic age, out of a total production of 36 million tons of iron-ore, while she imported in addition 3,800,000 tons of the same ore from Briey. Without the Lorraine iron-ore basin, which she took from France in 1871, Germany would have been unable to go to war, and she took care to secure the remaining portion of the field (*i.e.*, the Longwy and Briey basins) soon after the commencement of hositilities.

In England the Jurassic formation stretches as a broad band from the coast of Yorkshire to that of Dorset. The ironstones occur on four different horizons, namely, the Corallian, the Inferior Oölite, the Middle Lias and the Lower Lias.

The Corallian ironstones are at present not worked as a source of iron, although the Westbury bed is quarried for use in the purification of illuminating gas. In the Kent coal field a bed of oölitic ironstone, 16 feet thick, has been cut in the shaft of the Dover Colliery, at a depth of 593 feet from the surface. This ore contains, as mined, 33 per cent. of iron, 15 per cent. of silica, 9 per cent. of lime, 0.45 per cent phosphorus and 0.05 per cent. of sulphur. It is rather friable and may have to be sintered or briquetted before use in the blast furnace. On account of its favorable situation in a coal field and on the seaboard it is most

probable that steps will be taken to work this deposit in the near future.

The other Jurassic ironstones are all worked; and in 1917 accounted for over 80 per cent. of the total output of iron-ore in the United Kingdom, the remaining 20 per cent. being made up of hematite mined in Cumberland and Lancashire (10½ per cent.), blackband and clay-ironstone mined in the English and Scotch coalfields (8 per cent.) and sundry ores mined in Wales, Forest of Dean, Devonshire, Weardale, and Ireland (1½ per cent.).

Taking the Jurassic ironstones in descending order the proportion in which they were worked (in relation to the total production of the United Kingdom) in 1917,, and their iron-content are as shown in the table:

TABLE SHOWING RELATIVE PRODUCTION AND IRON-CONTENT OF THE JURASSIC IRONSTONES.

	Ratio to Total Production, Per Cent.	Average Iron Content (as Mined) Per Cent.
Inferior Oölite (Northampton and Rutland)	21	32
Middle Lias (Cleveland)	32	28
Middle Lias (South Lincolnshire, Leicestershire and Oxfordshire)	9	25
Middle Lias (Raasay)	0.5	23
Lower Lias (North Lincolnshire)	18.0	23
	80.5	27.6

COMPOSITION OF IRON ORES.

The average composition of the different ores is shown in the following table:

TABLE SHOWING AVERAGE ANALYSES OF JURASSIC IRONSTONES AS RECEIVED AT THE WORKS.

	Inferior Oölite (Northampton), Per Cent.	Middle Lias (Cleveland Var.), Per Cent.	Middle Lias (Leicester Var.), Per Cent.	Middle Lias (Oxfordshire Var.), Per Cent.	Lower Lias (Frodingham Stone), Per Cent.	Corallian (Dover Colliery), Per Cent.
Fe	32.5	28.1	25.2	24.0	22.7	33
Mn	0.24	0.41	0.23	0.27	0.96	—
SiO_2	14.7	11.8	10.9	10.2	8.1	15
Al_2O_3	6.1	10.2	8.0	7.6	5.1	—
CaO	2.7	4.7	9.6	12.2	18.2	9
MgO	0.4	3.5	0.6	0.6	1.0	—
S	0.10	0.26	0.11	0.06	0.16	0.05
P	0.60	0.47	0.25	0.23	0.31	0.45
Moisture	15.2	6.8	16.4	15.6	10.7	—

The Northampton ironstone is, in general, high in silica and low in lime, and contains 0.1 per cent. of sulphur and 0.6 per cent. of phosphorus. In part, it is smelted locally with limestone or with limey ironstone, obtained in the district, to neutralize its siliceous character. Some is sent to Frodingham and some to Middlesbrough for smelting with the ironstones of those districts; but the greater proportion goes to furnaces in the coalfields of Staffordshire, Derby and Nottingham, South Yorkshire and South Wales to be smelted in admixture with the calcareous blackband and clay-ironstones of the coal-measures and with tap-cinder.

The Cleveland ironstone is also siliceous and requires lime to flux it. It is high in alumina and sulphur and this feature militates against its use for making basic pig-iron, since the alumina-content makes it difficult to carry sufficient lime in the slag to ensure the production of a basic pig low in silicon and sulphur. To produce a suitable pig a considerable proportion of ores low in alumina, mainly of foreign origin, has to be added to the furnace charge. But by using molten metal direct from the blast-furnace and desiliconizing it in a mixer, basic open-hearth steel can be made from Cleveland ores without admixture with foreign ores.

The Frodingham ironstone almost invariably contains sufficient lime to be fluxed without the addition of limestone. It also carries about 1 per cent. of manganese and can therefore be smelted without the addition of manganese ore. These self-fluxing properties make it a most valuable ore, in spite of its low iron-content which averages only 22 per cent. The sulphur-content is 0.16 per cent. and the phosphorus, 0.31 per cent.

The Marlstone of South Lincolnshire, Leicestershire and Oxfordshire is on the whole a "limey" ironstone and is often self-fluxing. In places, however, where the surface waters have leached out the lime, it is siliceous. Its phosphorus-content averages 0.25 per cent.; sulphur, 0.1 per cent.

The following are average analyses of the limey and siliceous varieties, respectively:

It will be seen that chemically the change from the limey to the siliceous type, brought about by weathering consists of a loss

	Limey Ironstone (Unweathered Marlstone), Per Cent.	Siliceous Ironstone (Weathered Marlstone). Per Cent.
Fe	22.43	27.91
Mn	0.24	0.28
SiO_2	9.39	13.28
Al_2O_3	7.36	8.03
CaO	14.89	3.79
MgO	0.61	0.42
S	0.06	0.05
P	0.23	0.22
Moisture	13.85	20.56
Difference (combined water, CO_2 and O)	30.94	25.46
	100.00	100.00

of lime and carbon dioxide and an increase of all the other constituents—iron, silica, alumina and moisture. Physically, the change is from a compact bluish-green ironstone, consisting of carbonate of iron and lime, to a porous brown hydrated oxide of iron, or limonite. In the quarries the horizontal line of demarcation between the two varieties is often clearly discernible. Where, however, the "cover" consists of clay, shale or other impermeable material of sufficient thickness to hinder the downward percolation of the surface water, hydration and oxidation of the ironstone is prevented, and the green limey variety in that case extends up to the junction of the ironstone with the cover.

OCCURRENCE OF JURASSIC ORES.

Although poor in iron, the Jurassic ironstones are valuable because of their considerable thickness and widespread occurrence at only a slight depth below the surface. With the exception of the Cleveland district of Yorkshire, where the ironstone is now mined underground, the workings are nearly everywhere at the surface, the ironstone being quarried after stripping off an overburden of soil, sand, or clay as the case may be. Since the angle of the dip is usually small, or, in other words, the beds are practically horizontal, considerable areas can be worked before the overburden becomes too great for removal at a reasonable cost. As much as 60 feet of soft material (sand or clay) can be removed, and under favorable conditions probably 100 feet will be removed.

The different beds of ironstone vary considerably in thickness. The thickest is the Frodingham bed in North Lincolnshire. This ironstone is 25 to 30 feet in thickness, and consequently can be worked very cheaply by mechanical excavation. Before the war, the cost of the ore in wagons at the quarries (exclusive of royalty) was not more than 1s. (24 cents) per ton. Probably it is double that now.

The workable part of the Northampton ironstone varies from 6 to 13 feet, averaging about 8 feet. The lower portion of the bed is generally too poor in iron for economic extraction. During the early part of the war it was sold at 3s. 3d. (78 cents) per ton of crude ore. Subsequently, the price was fixed at 3s. 9d. (90 cents) per ton, plus ½d. (1 cent) for every 1s. 3d. (30 cents) rise in wages above the rate current on November 12, 1917.

The Cleveland Main Seam varies from 5½ to 12 feet. It is mined at depths ranging from 100 to 600 feet, the mines being worked on the bord-and-pillar system. The cost of the ore at the pit's mouth is now about 10s. ($2.40) per ton, as against 2s. (48 cents) to 4s. (96 cents) for the quarried stone. The output per man employed on surface and underground in the Cleveland mines averages 2.2 tons per shift, as against 4 to 15 tons for the quarried stone. In addition to the Main Seam, other ironstone beds, both above and below it, have from time to time been worked on a small scale in the Cleveland District.

PRODUCTION.

As compared with 1916 figures, the production of the Jurassic ironstones as a whole was increased by 45,000 tons per week, equivalent to 2⅓ million tons per annum. The increase reached this maximum in the first half of the year 1918. But it was not possible to maintain production at that figure on account of the calls of the Army on labor. The increase was made mainly in Northampton, Rutlandshire and Leicestershire, the quarries in these counties accounting for 50 per cent. of the total increase; but Cleveland accounted for 26 per cent. and Oxfordshire for 9 per cent.

The following table, showing the production of the Jurassic ironstone in relation to the total production of iron ore in the United Kingdom during 1918, is compiled from returns made to the Ministry of Munitions.

PRODUCTION OF IRON ORE IN THE UNITED KINGDOM DURING 1918.

	Tons.	
Cleveland	4,570,892	
North Lincolnshire	2,639,712	
Midlands	4,954,087	
Raasay	88,047	
Total Jurassic Ironstones	12,252,738	(80%)
Coalfields	1,119,215	
Wales and Forest of Dean	85,419	
Miscellaneous (Ireland, County Durham and Devonshire)	37,039	
West Coast (Hematite)	1,549,962	
Total Non-Jurassic Ores	2,791,635	(20%)
Grand Total	15,044,373	

NON-JURASSIC ORES.

Of the non-Jurassic iron ores of the United Kingdom, the most important are the hematite deposits of Cumberland and Lancashire. These ores are remarkable for their richness in iron and their freedom from both phosphorus and sulphur, and they therefore furnish a pig-iron very suitable for the acid Bessemer process, and yield an exceptionally pure steel. They are consequently in great demand; and this demand was emphasized during the war by the difficulty at one time experienced in securing sufficient supplies of hematite ore from Spain. Every effort was therefore made to push production to the utmost, and many abandoned mines were reopened in order to extract the pillars.

The deposits occur as masses of irregular shape in the Carboniferous Limestone, a formation which in this district rests unconformably on the old Skiddaw Slates, and is itself concealed in places by overlying Coal-measures and Red Sandstones, or by Boulder Clay. The existing mines are situated between Lamplugh in Cumberland and Ulverston in Lancashire, a distance from north to south, of 35 miles.

No doubt, besides the known deposits, many undiscovered ore-

bodies exist in the Carboniferous Limestone, that can only be found by systematic prospecting by boring. Already before the war, borings through the Red Sandstones had disclosed, south of Egremont, some of the largest ore-bodies that have been found in either county, with the possible exception of that worked by the Hodbarrow mine. The Beckermet, Ullcoats and Ullbank Companies are now engaged in developing and working these deposits.

Since the Carboniferous Limestone is of widespread occurrence in the United Kingdom, it might have been expected that valuable hematite deposits would have been discovered in other parts of the country. With the exception, however, of deposits of limited extent in South Wales and in the Forest of Dean, this has not proved to be the case. The South Wales hematite was worked fairly extensively to the northwest of Cardiff between the years 1840 and 1870, and yielded in the aggregate some 3 million tons of ore. But with the exception of the Llanharry mine, which still continues to produce about 60,000 tons of ore per annum, all work has stopped on these mines.

In the Forest of Dean the deposits, or "churns" as they are locally called, are chiefly characterized by their irregularity and small dimensions. The output of this field is quite unimportant, being less than 300 tons a week.

The only other important sources of iron-ore in Great Britain are the blackband and clay-ironstones, associated with the coal seams in the English and Scotch coalfields. These ores which once played a big rôle in the British iron industry, are now of small importance owing to the exhaustion of the larger and more profitable seams.

The total output from Scotch and English coalfields amounts to 1,120,000 tons per annum, of which 357,000 tons come from Scotland and 695,000 tons from North Staffordshire. In Scotland the ore is derived from narrow seams of blackband and clayband and from "balls" of ironstone brought down in working the coal.

In North Staffordshire there are (1) small seams of blackband associated with sufficient combustible material to permit of cal-

cination in the open without the addition of further fuel, and (2) seams of clay-ironstone which require the addition of fuel for calcination. By the calcination of these ironstones two products are obtained, (1) a high-grade material, containing over 60 per cent. iron, which is used for bottoming and fettling puddle-furnaces and for oxidizing purposes in the steel-furnaces; and (2) a slightly inferior quality containing 55 per cent. of iron which goes to the blast-furnaces.

CONCLUSIONS.

In the industrial recuperation of the United Kingdom, now that the war is over, the working of the low-grade Jurassic deposits which it is fortunate in possessing is destined to play a great part. This has been rendered possible by the great extensions to iron and steel works that have been initiated with Government assistance during the war. These works have been planned on the most modern lines, and possess on the same site by-product coke ovens, blast-furnaces, steel works and rolling mills. They are designed for the basic process of steel-making and will be fed with home ores. In choosing the sites for these works regard has been paid to the situation of the raw materials—ore, fuel, and flux—required to supply them. On the completion of these extensions there should be no necessity for this country to import a single ton of foreign steel. Before the war something like 2½ million tons of steel, in the form of slabs, blooms and billets, were imported into Great Britain annually, mainly from Germany.

But for success in this great undertaking cheap ore and fuel are essential, and these can only be obtained, in face of the greatly augmented cost of labor and material, which is a legacy of the war, by an all-round increase in efficiency, embracing capital, engineering, and labor-capital by the installation of up-to-date equipment, engineering by improved mining methods, and labor by an increased output per man per shaft.

EDITORIAL

GEOLOGISTS AS EXPERT WITNESSES.

I cannot fall out with or condemn a man for an error, or conceive why a difference in opinion should divide an affection; for controversies, disputes, and argumentations, both in philosophy and in divinity, if they meet with discreet and peaceable natures, do not infringe the laws of charity.—*Sir Thomas Browne.*

Discussion over the functions of expert witnesses, and over the relations of such witnesses to judge, jury, and litigants, is by no means new, and legal periodicals and treatises on evidence contain a considerable body of literature on expert testimony. As is natural, by far the greater part of this literature is concerned particularly with medical testimony, and the subject of geologists as expert witnesses has come into prominence only in comparatively late years.

It appears that the English courts summoned experts to advise them as early as 1345. The first instance on record in which expert testimony was submitted to a jury was in the case of Alsop *v.* Bowtell, in 1620, the witnesses being physicians. A more famous case was the trial of the so-called Suffolk witches in 1665, during the reign of Charles II. In this trial the kindly Sir Thomas Browne, dear to lovers of English prose and whose generally tolerant spirit is shown by the quotation above, testified as a physician that the plaintiffs had undoubtedly been bewitched and the accused, two hapless old women, were convicted and executed. Thus it will be seen that expert testimony very early gave some ground for the rather general disrepute into which it subsequently fell. As Judge Bartlett[1] has pointed out, had Sir Thomas been subjected to such searching cross-examination as is now employed, his testimony would have been badly shaken.

[1] Bartlett, Willard, "Medical Expert Evidence: the Obstacles to Radical Change in the Present System," *Amer. Law Review*, vol. 34, pp. 1–15, 1900.

According to Professor Gray:

If we go back to the earlier history of expert witnesses, the only persons permitted to give skilled or expert testimony were scientific men called to give accepted principles of science. The only justification was, that the court might have information on scientific matters—matters beyond the knowledge and capacity of the court (or jury). Then only men versed in the particular science involved in the case could be called. Usually but a single expert was heard. Such witnesses were called because of their special scientific knowledge of the question at issue. They were supposed to give a scientific, disinterested, impartial statement of settled and accepted principles applicable to the case in hand. The courts always objected strenuously to, and attempted to exclude fancies, mere guesses, and theories not generally accepted by science. The courts condemned diversity of expert opinion and spoke often of principles universally accepted by science. These were principles supposed to be worked out in a disinterested way by those devoting their lives to that particular science.[2]

In the course of time, the status of the expert witness has changed and in many modern trials the contending parties have called large numbers of highly paid experts whose partisan character is generally recognized and is amply shown by the unanimity with which the experts on each side stick to opinions favorable to their respective clients. As Endlich has said:

A fundamental vice of our present system is its partisan character and tendency. Not only do the public and juries regard the generality of experts, employed as they now are, as mere partisans for the side by which they are called, but many lawyers so treat them, and many experts consent to be so considered and so consider themselves.[3]

Mr. T. A. Rickard, discussing this subject editorially, remarks:

A specially regrettable phase of the question is the engagement of professors as witnesses, or "experts," in lawsuits. They become hired advocates for one or other side; ceasing to be scientific, they become crassly commercial. In suits brought against public utility corporations, it is not uncommon to find professors serving as hired advocates

[2] Gray, John H., "Expert (or Opinion) Testimony in Rate Valuation Cases," *The Utilities Magazine*, vol. 1, p. 197, 1916.

[3] Endlich, G. A., "Proposed Changes in the Law of Expert Testimony," *Amer. Law Review*, vol. 32, p. 862, 1898.

to buttress an invasion of private rights; in such cases the honesty of the testimony not infrequently is ridiculed by the opposing side, and even by third parties, to the injury of the University with which the witness is identified. The most glaring examples of such scandals are afforded by apex-suits over mining properties, in which a number of honorable professors on one side swear a thing is black, while an equal number of equally honorable professors on the opposite side swear that it is white.[4]

This statement, although couched in terms of exaggeration, contains a substratum of truth and well illustrates the prevalent popular impression concerning expert testimony. Nor is disapproval confined to the lay public; many judges, sorely tried by the conflict in testimony that should be impartial, have been tempted to exclaim with Mercutio "A plague o' both your houses!" and some have even instructed the jury to disregard the expert testimony entirely. Unquestionably the modern practice in mining law suits of employing numerous highly paid geological experts on each side, has enormously increased the costs of the litigation, not only by the fees paid but by greatly swelling the bulk of the testimony and by protracting the hearings.

The fundamental difficulty as regards the present system of taking expert testimony appears to lie in the antithetical relation that exists between the scientific and the legal attitude of mind. The life of a scientific man is or should be devoted to the search for truth and, what is just as important, to the promulgation of truth. He should subject all evidence to the most critical and impartial scrutiny and be constantly on his guard against becoming an advocate, even for his own conclusions. Tradition and precedent have no weight with him and authority, although entitled to respect when founded on observance and mastery of the principles of scientific method, does not bind him. The lawyer, on the other hand, while his intellectual integrity may be unimpeachable and while he may employ the methods of science in certain branches of his profession, is, in ordinary practice,

[4] *Mining and Scientific Press*, Jan. 17, 1920, p. 74.

an advocate. It is his business to win the case for his client and his efforts towards that end consist largely in a search for precedent in the form of prior decisions. He is confessedly and properly a partisan and searches for those facts that will help his case. He may also seek for those facts that are opposed to his client's contention, not, like the scientific man, to make them known, but to arm himself against their possible introduction as evidence by opposing counsel. In other words, he may earnestly seek the truth but it is not necessarily his purpose to speak the truth, the whole truth, and nothing but the truth. He endeavors in every way possible to create an atmosphere favorable to the contention of his client and to play upon the feelings as well as the reason of the jury. These two attitudes of mind are so diametrically opposed that it is rather remarkable that practicing lawyers, when raised to the bench, should be able to adjust their mental processes to the judicial attitude which in many respects is closely similar to that of the man of science.

In view of the fact that many eminent and honorable men of science have accepted positions as expert witnesses, it is not justifiable to assert roundly and without qualification that such acceptance was morally wrong. Certainly the intent of wrongdoing has usually been absent and many such witnesses may have been thoroughly convinced of the inherent righteousness of the cause espoused. Nevertheless, I believe that it must be admitted that the geologist who becomes an expert witness for one side in mining litigation places himself in a scientifically false position.

Recently, in a very interesting paper, Mr. Locke has suggested that mining geologists so-called, might be divided into two professional groups—"court geologists" and "ore-hunting geologists." He points out that the mental qualifications for the two branches of the profession are not the same—that the court geologist must have the mind of an advocate whereas the ore-hunting geologist should have the judicial temperament. He cites the Elm Orlu *v.* Butte and Superior lawsuit of 1915 in which five eminent geologists on one side were unanimous

against five equally eminent and unanimous geologists on the other side, both as to matters of fact and to inference or opinion. He puts the case as favorably as possible for the expert witnesses when he maintains that this unanimity in difference, so little creditable to science, involves no personal dishonesty. He explains it by unconscious prejudice.

> To a given witness, sustaining a particular contention, the prejudice seemed to lie wholly with his opponents; he asked himself conscientiously again and again how those able men could have achieved such an inconceivable bigotry. And yet among the complicated elements of an agument, where, in case after case, the weight of a straw would be decisive, he was himself putting the straws all on one side; instead of letting them lie where they fell, as the scientist must do, he unconsiously shifted them a little, and then, proudly and confidently, showed the emphatic result.[5]

Perhaps there was no dishonesty in the ordinary moral sense: perjury is a harsh word. But if it be considered that the difference sprang from unconscious prejudice, is there not a more subtle intellectual honesty that is violated when a scientific man, with the example of this and other cases before him, permits himself to be placed in a position wherein he knows he may have to be consciously dishonest or is at best likely to interpret facts through the spectacles of prejudice? It is admitted that such work is not only profitable but is often intensely interesting, and may give opportunity for scientific observations of value. The temptation to engage in it may be very strong. Can a man who cherishes the highest ideals of scientific work afford to yield to it, under the existing practice of employing expert witnesses? Opinions on this question will differ, but my own belief is that in general he can not. Others may perhaps present grounds for a different conclusion, in the department of this journal devoted to *Discussion*. It has been said that a witness before he undertakes a case may be sure of his ground. As a rule no geologist can tell in advance what all the developments in a suit will be, and it is doubtful whether a geological expert witness can escape

[5] Locke, Augustus, "The Two Professions of Mining Geology," *Mining and Scientific Press*, Jan. 31, 1920, p. 162.

being a partisan witness when he is employed by one of the litigants with the obvious intent that he shall help to win the case.

Various remedies have been proposed to improve existing conditions as regards expert testimony, only a few of which need here be considered. It has been suggested that cases in which scientific questions are involved be tried before a jury of experts. This is the practice in Germany and to some extent in France. It is impracticable in this country, as the present jury system is too deeply rooted to be changed and because scientific questions as a rule are only a part of the issue before the court. Moreover, in mining cases it would be impossible for a jury of the traditional size to acquire the same first-hand knowledge of facts as is now accessible to geological experts in advance of the trial. Finally, it would be exceedingly difficult to obtain the necessary jurors and would impose insufferable hardship on men of the class from whom the choice would have to be made.

A second suggested expedient is the appointment of official experts to take the place of partisan experts by the litigants. As Dean John H. Wigmore, of the Northwestern University School of Law, a well-known authority on evidence, to whom I am greatly indebted for advice and suggestions in the preparation of this editorial, points out:

> This is equally futile; first, because it interferes with the traditional right of the parties to adduce such evidence as they think useful; and secondly, because it would commit the fate of such issues completely to a body of men who, under certain political conditions, would be wholly unreliable, and the new state of things would often be worse than the old.[6]

It has been proposed that the court appoint an expert to sit with him and advise him. The various authors of this suggestion have not all clearly stated whether such an appointee should share the bench with the judge or be a witness, subject to cross-examination. Neither have they all specified whether or not the litigants should be permitted to have their own expert witnesses. The suggested change has some analogy with prac-

[6] Personal letter of Feb. 11, 1920.

tice in admiralty cases where skilled assessors are summed to form a part of the tribunal and special expert nautical witnesses are denied to the parties at law. Lawyers and judges, however, appear to be generally opposed to permitting scientific experts in other cases from occupying any other position than that of witness, subject like other witnesses to cross-examination. Sir James Fitzjames Stephen, who believes that the present system should be maintained unchanged, comments vigorously on this particular point. He says:

> Our present system provides a definite place and definite rights and duties for the parties, the judge, the jury, and the witnesses. What room there is for any other persons in the proceedings I do not see. It is impossible to say what an expert is to be if he is not to be a witness like other witnesses. If he is to decide upon medical or other scientific questions connected with the case so as to bind either the judge or the jury, the inevitable result is a divided responsibility which would destroy the whole value of the trial. If the expert is to tell the jury what is the law—say about madness—he supersedes the judge. If he is to decide whether, in fact, the prisoner is mad, he supersedes the jury. If he is only to advise the court, is he or is he not to do so publicly and to be liable to cross-examination? If yes, he is a witness like any other. If no, he will be placed in a position opposed to all principle. The judge and the jury alike are, and ought to be, instructed only by witnesses publicly testifying in open court under oath. It never would be, and never ought to be, endured for a moment that a judge should have irresponsible advisers protected against cross-examination.[7]

One of the simplest and probably the most practical suggestion of all is that the judge himself, on any issue involving expert scientific knowledge or opinion, should call in one or more experts, such expert or experts being merely additional to those called by the litigants. Concerning this plan, Dean Wigmore writes:

> Modest as it seems, this expedient would, I believe, remove most of the present abuses. As soon as the clash of opinion appeared between the partisan experts, paid by the parties, the jury would turn for its

[7] "History of Criminal Law in England," Macmillan & Co., 1883, vol. 1, pp. 574–575.

real guidance to the impartial one selected and summoned by the judge, and his conclusions would have a decisive weight with the jury. At the same time there would be no appearance of suppressing possible truth by excluding the parties' experts; and the experts called by the parties would be of service in exposing occasionally the errors of the official expert. There are, of course, a few details which would assist the whole process; however, not essential to it:

(*a*) The official expert should be allowed to draw up his statements in the form of a report and to read this in the first instance as his testimony.

(*b*) The Judge should be authorized to require a conference before trial between the official expert and all the experts to be summoned, so as to reconcile needless misunderstandings which now develop through the keeping apart of the experts and the open baiting by the parties' counsel on the trial.

(*c*) And of course the official expert should be subject to cross-examination, if desired by the parties.[8]

Although Dean Wigmore, in his letter quoted, does not specifically state that the experts called by the judge should be paid from the public treasury as part of the official expenses of the trial, such is the natural conclusion and is the usual recommendation in connection with this particular suggestion.

Michigan in 1905 passed a law providing that no expert witness, except by court order, should receive compensation in excess of ordinary witness fees and that not more than three experts should testify on each side. It further provided that in criminal prosecutions for homicide, where the issues involved expert knowledge or opinion, the court should appoint one or more suitable disinterested persons, not to exceed three, to investigate and testify. Such experts were to be paid by the county and their appointment was not to exclude other experts called by the parties. This statute was held to be unconstitutional altho the decision is contrary to the opinion held by some excellent legal authorities.

A more general statute, which is understood to have the approval of the American Bar Association and the American Medical Association, has been proposed in Maine but has not yet become law. Sections 1 and 2 read as follows:

[8] Personal letter of Feb. 11, 1920.

Section 1. In any case, civil or criminal, in the supreme judicial court, or any superior court, when it appears that questions may arise therein upon which expert or opinion evidence would be admissible, the court, or any justice thereof in vacation, may appoint as examiner one or more disinterested persons qualified as experts upon the questions. The expert at the request of either party, or of the court or justice appointing him, shall make such examination and study of the subject matter of the questions as he deems necessary for a full understanding thereof, and such further reasonable pertinent examination as either party shall request. Reasonable notice shall be given each party of physical examination of persons, things and places, and each party may be represented at such examinations.

Section 2. At the trial of the case, either party or the court may call the examiner as a witness, and if so called he shall be subject to examination and cross-examination as other witnesses. For his time and expenses incurred in the examination and in attending court as a witness he shall be allowed by the court a reasonable sum, to be paid from the county treasury as part of the court expenses. The court may limit the witnesses to be examined as experts to such number on each side as it shall adjudge sufficient for an understanding of the contention of the parties on the question.

Any attempt to limit the fees paid to expert witnesses to the ordinary witness fees appears neither wise nor just. The two classes of witnesses are very different. The ordinary witness testifies merely as to facts such as require for their apprehension no exceptional training or ability and which as a rule have come to his attention without particular exertion on his part. The expert witness on the other hand is required to draw upon knowledge and experience that have been gained by arduous application to his specialty and, in mining suits at least, is likely to be called upon to conduct more or less elaborate technical or scientific investigations in advance of the trial. The fees paid to an expert witness should be comparable with those that he obtains in the usual practice of his profession and such as are consonant with the honor and dignity of his position as a scientific expert chosen by the court. To limit compensation to ordinary witness fees would defeat the whole object of the proposed reform—namely to obtain the services of impartial experts of

the highest type in an earnest and persistent effort to get at the truth.

It may be objected that in mining cases an expert chosen by the court would not be in a position to plan and direct the large amount of preparatory work, including underground development and the construction of maps and models, that is now carried out under the direction of the experts for each side. It is to be observed, however, that there is nothing in the proposal to prevent each party to the suit form having its own geological experts in court or from having its evidence prepared under the direction of geologists who need not appear as witnesses. It is believed that the tendency would be to keep the litigants' geologists out of court proceedings, and in any event their number should be limited to three or less on a side. In this connection much might be accomplished by geologists themselves through a general recognition of the fact that it is more in keeping with the honor of their profession to appear in court as an impartial witness called by the judge than as a partisan witness called by one of the parties, and through the establishment of definite standards of professional ethics as regards expert testimony.

Some have feared that the judge might not make a wise choice. Presumably, however, if he is worthy of his high office he will not depend entirely on his own knowledge and will know where to go for advice. He might well consult the litigants themselves and if possible choose a man acceptable to both sides. There might even be some provision for excluding a man concerning whose ability or impartiality either party lacks confidence.

As probably over nine-tenths of our mining cases involve interpretation of the absurd apex principle in our mining law the abolition of extralateral rights would be a radical and heroic cure for evils of the present system of taking expert geological testimony. Professor Kemp[9] in a recent editorial in this *Journal* has well presented the case for a revision of the law

[9] Kemp, J. F., "Geology in the Law," Econ. Geol., vol. 15, pp. 259–265, 1920.

under which lode claims are located. The change is certainly desirable but probably can not be made wholly retroactive and a large proportion of the mining law suits of the future are likely to be concerned with as yet undeveloped claims that have been located under the existing law. The reform, even if it comes soon, will have come too late to remove more than a small part of the heavy incubus that a law intended to be generous to the miner has saddled upon the mining industry.

Expert testimony has often been referred to as "opinion testimony" in view of the fact that expert witnesses, unlike ordinary witnesses, are not restricted to the introduction of facts as evidence. This designation is somewhat misleading, particularly with reference to geological witnesses who often do testify as to facts observed by them. Nevertheless, geologists in court are frequently required to express opinions on legal interpretations and legal definitions rather than on scientific conclusions or scientific definitions. They are thus led into a field that is not scientific and in which their opinions have far less value than a jury is likely to suppose. A geologist, for example, may have an exact conception of what he means by *lode* when he uses the word in a scientific paper; but when he undertakes to say what lawyers mean by *lode* or what the word signifies in certain statutes or legal decisions, he rashly undertakes to solve mysteries to which his studies have given him no key. It should be recognized by judge, lawyers, and jury, in partial reform of the present system, that a scientific expert properly cannot be expected to express opinions on such matters.

F. L. RANSOME.

U. S. GEOLOGICAL SURVEY,
WASHINGTON, D. C.

DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

RELATION OF OIL POOLS TO ANCIENT SHORE LINES.

Sir: Mr. W. F. Jones's recent paper on "The Relation of Oil Pools to Ancient Shore Lines"[1] is of considerable interest to petroleum geologists in that it treats of one of the important factors concerned in the origin of oil accumulations. There can be little doubt that regions where oil occurs are in some degree related to the positions of ancient shore lines. But has not Mr. Jones very greatly exaggerated, if he has not misinterpreted, the significance of this factor as a control in the localization of oil pools? Apparently he is led to the conclusions, for Pennsylvania and Oklahoma, (1) that the oil has been derived from original lagoonal deposits of mud which were more or less isolated and elongate and were essentially parallel to the ancient shore lines; (2) that the present position and shape of oil pools closely conform with the position and shape of the lagoonal deposits; (3) that, consequently, there can have been very little lateral migration of oil from the oil-yielding shales; (4) that structural control of the localization of oil pools is almost of negative value, the coincidence of anticlinal structures and oil pools in some instances, such as Cushing, being fortuitous; and (5) that the accumulation of oil may have been predeformational, *i. e.*, antedating the folding.

[1] ECON. GEOL., Vol. XV., pp. 81–87, January, 1920.

It is true that Mr. Jones, near the beginning of his paper, states that structure may govern migration and accumulation "where conditions are right as regards size of pores in the sand, viscosity of the oil, and sufficient dip of the roof of the porous bed,"[2] but the trend of his arguments is against structural control in the states of Pennsylvania and Oklahoma. While his subtitle, "Preliminary Paper," gives us assurance that we may hope for further discussion of the subject, especially in regard to other states, it may not be out of place to make a few suggestions at this time. In doing so, we shall not limit ourselves to Oklahoma and Pennsylvania since we feel that principles which work in these states will apply elsewhere, and vice versa, and that it is questionable whether in these two states the inferred generalization can be made that dips are everywhere inadequate for lateral migration of oil under existing or past conditions of oil viscosity and sand porosity.

That petroleum has been derived from muds or shales which were rich in organic matter we do not question; but that all feeding mud or shale bodies (if we may so call them) in Oklahoma and Pennsylvania were of the lagoonal type, narrow and elongate parallel with the shore line, is not so certain. Some of these deposits may have been of the deltaic variety, and if so, their form was probably very different from that of the typical lagoon.

If we should admit the predominance of the lagoonal kind of deposit at any one time during the progress of sedimentation, would not the characteristic form and relations of the deposit and its surroundings be largely lost as a result of transgression or regression? In other words, the general effect, let us say, of transgression would be to yield mud bodies of considerable lateral continuity. As the present writer pointed out in a previous paper,[3] "estimates of the comparative total thicknesses" of sandstones, shales, and limestones in oil-producing formations "have shown that the average proportion of sandstones to

[2] *Op. cit.*, pp. 81–82.

[3] Geologic Factors in Oil Prospecting, ECON. GEOL., XIV., pp. 480–490, 1919. Citation, p. 481.

shales plus limestones is between 10 per cent. and 20 per cent. of the whole formation." In such a series the shales are more likely to be the continuous members and the sandstones the discontinuous or lenticular members. As a matter of fact, the evidence from cross sections in the oil fields demonstrates that the shale strata are usually of greater lateral extent than the sandstone strata. Although lenticular sands have a good deal of irregularity of position, form, and trend, yet they no doubt have a prevailing elongation roughly parallel to the shore line of the time, for each, when it was deposited. Thus we are led back to the conception, pretty generally conceded by geologists, that oil pools may be, and in fact often are, limited in their extent by lateral pinching of the reservoir sands and that this is the factor which causes a rough parallelism of oil pools and ancient shore lines. One should observe that this relation does not militate against the possible (or probable) coöperative control by structure in producing the pools. Furthermore, in itself it is not contrary to the theory of lateral migration.

As regards this problem of lateral migration, Mr. C. H. Wegemann recently[4] showed that, in the Salt Creek field in Wyoming, the producing area of the first Wall Creek sand, which is 150 ft. thick, is about one fourth that of the second Wall Creek sand, which is only 40 ft. thick; *i. e.*, that the thicknesses of these sands bear approximately the same relation to each other as do their productive areas, but in inverse ratio. The oil in the thicker sand does not extend so far down on the flanks of the structure as in the thinner sand. Since the sands are open, this would seem to indicate lateral migration of the oil to its present position, for there is reason to believe that the area of contact of the shale and sandstone is not unlike in the cases of the two sands. We believe, with Mr. Wegemann, that this oil may have been yielded from only a few inches, or perhaps at most a few feet, of thickness of the shale immediately contiguous with the sandstone. If this is true, we must admit considerable lateral migration,

[4] In a paper delivered at the Dallas meeting of the American Association of Petroleum Geologists in March, 1920.

though not necessarily from beyond the adjacent synclinal troughs.

Mr. Jones is inclined to believe in predeformational accumulation. If accumulation were vertical, as he suggests, and lateral migration did not occur, this would mean that wet oil sands should yield oil from their upper parts and water from their lower parts all over their extent, both on anticlines and in synclines, wherever overlain or underlain by shales that were oil-yielding. Yet we frequently find, of course, that sands producing oil on anticlines, even in Pennsylvania and Oklahoma, yield water on the flanks of the structure in spite of the fact that the adjacent shale is continuously in contact over an area much greater in extent than the productive area. As evidence that post-deformational accumulation does take place, at least in Wyoming, Mr. Wegemann, in the paper above referred to, cites the case of the Shannon pool where the oil has accumulated against a fault which was almost surely later, geologically, than the folding in the region.

Although we realize that some of the instances mentioned relate to fairly steeply dipping beds, yet we can see no reason why, if the principles of lateral migration and postdeformational accumulation are applicable in one region, they may not also be applicable in another. Mr. McCoy's experiments, cited by Mr. Jones, are illuminating and ingenious, and they certainly help us to interpret past conditions, but we must not forget the time factor, which can never be attained in laboratory experiments. Scientists are inclined to become prejudiced by the results of almost momentary experiments.

Summarizing, we believe:

(1) That, in a majority of cases, the rough parallelism of oil pools and ancient shore lines is due, not to the form and position of mud or shale deposits which yielded the oil, but rather to the form and position of the reservoir sands which now contain the oil;

(2) That lateral migration of oil has occurred, sometimes for distances of several miles, but probably not for distances of many miles;

(3) That the distance of such lateral migration depends upon such factors as the quantity of oil yielded by the shale, the effective porosity of the sands, the viscosity of the oil, the dip of the strata or other avenues of migration, the capacity of the reservoir in which oil accumulates, and, above all, the length of time during which conditions for migration prevail;

(4) That there is no good reason for the view that folding marked either the end or the beginning of oil migration, a process which may perfectly well have gone on before, during, and after deformation under suitable conditions such as have been mentioned above under (3); and,

(5) That structural conditions and water conditions are probably the two main controlling factors in the position and form of oil pools, porosity variations and pinching of sands, although important, being merely modifying factors. By this we do not mean to imply that the "modifying factors" may not in some instances obscure, or even overbalance, the effect of the "controlling factors."

FREDERIC H. LAHEE.

SUN COMPANY,
DALLAS, TEXAS.

REVIEWS.

Outlines of the Geology of Brazil, to accompany the Geologic Map of Brazil. By JOHN CASPAR BRANNER. Bull. Geol. Soc. of Amer., Vol. 30, pp. 189–338; plates 7; colored geological map, 37″ × 40″; scale about 80 miles to inch. On sale by the Secretary of the Geological Society of America; at the American Museum of Natural History, New York City. $3.35. A translation in Portuguese is in preparation.

At this time of our growing commercial relations with Brazil, the above work by Dr. Branner is most opportune. It will furnish engineers and business firms, looking to the development of mineral resources in the great republic of South America, with a compendium of extreme value. Geologists, as well, will welcome the summary of an extensive but much scattered literature. Since the work has been done by one who has spent years in the study of Brazil on the ground, and has kept in close touch with it during his later residence in this country, the results are both thorough and authoritative.

From the map we see at once that, in the large way, the Pre-Cambrian crystalline rocks, gneisses, schists and granites, appear as a wide band along the southeastern Atlantic coast for over 2,200 miles. They range from 500 miles broad at Cape St. Roque, at the shoulder of South America, to disappearance in the northern part of Rio Grande do Sul; but widen again at the Uruguayan border. They also appear as a broad east and west band along the northern frontier with the Guyanas and Venezuela. They extend from the Atlantic to the western boundary with Colombia. Although a great central area of Brazil is as yet unmapped. the heart of the country, so far as known, consists of later strata, which at the southwest along the boundary with Bolivia, Peru, and Ecuador, extend 2,500 miles in a northwest line. As one passes, however, northeast, the area covered by these strata, narrows to about 700 miles at the Atlantic coast, where they range from the mouths of the Amazon eastward. Around the borders, the Paleozoic rocks appear in parallel fringing bands. On the southeast and southwest, Triassic and Cretaceous strata are extensively developed; while to the north, along the course of the Amazon and in the area of its upper tributaries, Tertiary beds predominate. In the very heart of the country as stated above, a vast area awaits the geologist.

After a general introduction covering sources of information and a stratigraphic review, Dr. Branner takes up the 21 individual states in alphabetical order. Under each are given summaries of previous investigations, of the general geology, of the economic geology, of the previous geologic maps, and of the bibliography. After the treatment of the several states, the economic geology is discussed as a whole. First the metallic minerals are taken up in order, and second the non-metallics. Under the former, iron and manganese command especial interest in this country. While the treatment is very condensed, a reader is placed in immediate command of all the literature so that he can go to first sources in a large library. The notes on platinum cannot fail to awaken interest, since in small quantities, the metal has long been known in the gold and diamond placers of Minas Geraes. Under the non-metallic, the notes on petroleum and oil-shales, mostly bibliography, will be found of interest; and the longer treatment of diamonds and carbonados will especially attract those interested in these products of exalted present prices.

A summary of the mining laws of Brazil; another of works of travel; and some good advice regarding climatic conditions complete the monograph.

All friends of Dr. Branner, who is now President-emeritus of Stanford University, will rejoice with him over the completion of what has been a life work. No American geologist has ever possessed to a greater degree the confidence and esteem of his colleagues; and one only needs to read the dedication to him of the translation of Agricola by Herbert C. and Lou H. Hoover, to learn of the regard felt for him by his old students.

J. F. KEMP.

Prospecting for Oil and Gas. By L. S. PANYITY, 249 pp. Wiley & Sons, New York, 1920.

The people of the United States, and of a good many other parts of the world, are much interested in oil and gas. Petroleum and its products are a necessity in modern industry and natural gas is one of the most valuable of all domestic and industrial fuels. Not only, therefore, is the public at large concerned directly or indirectly with the finding of an adequate supply of these natural resources, but an increasing number of workers are engaged in finding, producing, and marketing them. The development of the oil and gas business has been so rapid in recent years that the descriptive literature, especially geologic and technologic is not large, and hence books relating to oil and gas are in wide demand.

"Prospecting for oil and gas" is intended to treat the geologic conditions under which commercially important accumulations of these

fuels occur, and the methods of locating and developing them. As stated in the preface, the author believes that his work will clearly explain to the "practical oil man" and the general public the methods of geological investigation, and bring them "into a more intimate relationship with the geologist." He also cherishes the hope that the treatise will be used as a manual by "those who intend to take up and follow the profession of oil and gas geology." The book is primarily written, therefore, from a geological viewpoint.

Although at least one fairly good, but brief, volume on petroleum geology has appeared—there are also some poor ones—the field is by no means very thoroughly covered. First examination of this new book calls attention to its execllent press-work, clear illustrations and general pleasing appearance. The general plan of treatment is good, but the most cursory notice of the text reveals a very disappointing failure to present even the simplest subject matter in an intelligible manner. The editorial work, also, is quite the poorest that the reviewer has ever seen. On account of its very general crudity of expression, errors of statement, the irrelevance of parts of the included matter and the omission of important subjects, the present work is, unfortunately, an extremely unsatisfactory expression of the principles of petroleum geology.

Many of the statements are so extremely involved that they may hardly be understood. Very commonly two or more entirely distinct, or only slightly related ideas are combined in a single sentence. Clauses, phrases and words without antecedents, or improperly placed with reference to antecedents, are almost the rule rather than the exception. Capitals are used inconsistently, and in many cases undesirably if not improperly. Some words are used incorrectly. It is not possible within the limits of a brief review to point out more than a very few typical examples, taken at random, of the scientific inaccuracies and the literary impossibilities with which the book is filled.

"One speaks of crude oil as having either a paraffin base or an asphalt base, depending on the residue remaining after the evaporation of the lighter constituents, which gives rise to several classifications to which hydrocarbons so readily lend themselves" (p. 1).

"The main production of the remainder of the oil-producing states *are* paraffin oils" (p. 6).

"Originally they (igneous rocks) were at a very high temperature so no living animals or plants were in them at the time of their formation, and are, therefore, unfossiliferous, and as they are found in almost any form and shape imaginable, are spoken of as unstratified rocks" (p. 10).

"The amount of sedimentary rocks that *have* been formed this way *are* enormous" (p. 12).

"Supposing that after folding another rising and lowering of the land level takes place, further erosion and deposition become possible on the already deformed sediments, causing more and more complicated folding and unconformities, or perhaps obliterate previous folds" (p. 14). The author's conception of the geologic principles which control the formation of sedimentary rocks, as stated in the pages of this book, is very vague and apparently partly in error.

"Such are known as *transitory* rocks" (p. 17). "The Permian . . . marks the *transitory* period between the Paleozoic and Mesozoic times" (p. 26). The proper word is *transitional.*

In the tables on pages 110–111 "*flora* and *fauna*" are incorrectly used as synonymous with plants and animals.

As examples of the numerous scientific inaccuracies and mis-statements, the following are noted at random.

The correlation table on page 20 represents as subdivisions of the "Genevieve formation" (Sainte Genevieve is probably meant), the Chester, St. Louis and Warsaw. No other writer has hinted at such an interesting or novel correlation. The Hackberry shale, Cedar Valley limestone and Independence shale (not the accepted nomenclature) of the Iowa Devonian, is referred to the Lower Devonian. It has always previously been regarded as indubitably Middle and Upper Devonian. Numerous similar errors are found throughout the table.

It is indicated (p. 22) that rocks of sedimentary origin are absent in the Archean. This is contrary to the findings of many geologists.

"The oldest fossil-bearing sedimentary rocks are in the Paleozoic Era" (p. 22). Well-authenticated fossils, described in all recent text-books of geology, were known from rocks older than the Paleozoic.

Graptolites are referred to the *Lower* Cambrian and it is stated that no vertebrates existed in the Ordovician (p. 23). This advances the previously known earliest occurrence of the graptolites an important distance, and disregards the extensive deposits of fish remains in the Ordovician rocks of the west.

"Crinoids make their first appearance (in the Silurian)." The author perhaps places the numerous crinoids of the Ordovician in some other biologic division.

"In a strict sense, almost anything found in any state of preservation in the rocks may be considered as fossils" (p. 109). This rather all-inclusive definition is interesting but very inaccurate.

Much of the chapters on General Geology and Fossils can hardly be considered relevant in a book on prospecting for oil and gas. It is certainly not very important, in seeking to locate commercial bodies of oil and gas, to know that Ordovician trilobites could curl up and had

faceted eyes (p. 23), that a few fish appear in the Silurian (p. 24), that cystoids were almost extinct in the Devonian or that amphibians appeared in the Mississippian (p. 25), or that *Archeopteryx* (of which only two specimens are known) lived in the Jura-Trias (p. 26). The biologic lists, charts, descriptions and illustrations (pp. 110–134) are of very little practical value, partly because they apply only in small degree to oil field problems, and partly because of the miscellaneous selection of the forms which are illustrated. Even the geologic age of some of the fossils is incorrectly given, and in some cases the names are interchanged.

Generalized geologic sections for a few random parts of the United States are included in an appendix, with miscellaneous tables. So many of the very important oil and gas producing regions, such as Oklahoma, northern Texas, Kansas, California, Illinois, Louisiana and Kentucky, are not represented, and a number of regions in which no important oil or gas deposits are known are represented, the relation to oil and gas geology is not clear.

Without specific mention of many other unsatisfactory features, it appears to the reviewer that "Prospecting for oil and gas" by Panyity, will hardly fill the need of a good book in the field of petroleum and natural gas geology.

RAYMOND C. MOORE.

SCIENTIFIC NOTES AND NEWS[1]

MR. JOHN T. REID will be at his office in Lovelock, Nevada, during the summer.

O. E. MEINZER, of the U. S. Geological Survey, returned to Washington in April. He was investigating the ground water problems of the islands under a coöperative agreement between the Territory of Hawaii and the U. S. Geological Survey.

C. WYTHE COOK is on furlough from the U. S. Geological Survey for the purpose of oil exploration in Columbia.

A. C. BOYLE, JR., professor of mining engineering and economic geology of the University of Wyoming, spent the Easter vacation in and around Salt Lake City, with a class of ten students. Visits were made to Park City, Bingham and Alta, and studies were made along the west face of the Wasatch Mountains as far north as Ogden, Utah.

ROBERT T. HILL has been reëlected president of the Southwestern Geological Society.

HOYT S. GALE, of the U. S. Geological Survey and Bureau of Mines, has taken a five months' furlough for oil work in Bolivia.

O. B. HOPKINS has left the U. S. Geological Survey, and has entered private employment as an oil geologist.

JOSEPH T. SINGEWALD, JR., professor of economic geology at the Johns Hopkins University, has returned from Peru, where he has been engaged in geologic investigations during the past few months.

C. J. DEAN, who left the U. S. Geological Survey to enter the employ of the Sinclair Oil Co., is in Bogota.

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

NELSON H. DARTON has been given leave of absence from the U. S. Geological Survey, and is making private oil investigations in northern Mexico.

HORACE V. WINCHELL, of Minneapolis, and Fred Searls, Jr., of San Francisco, are at Wallace, Idaho, in connection with the litigation between the Federal Mining & Smelting Co. and the Hecla Mining Co.

H. D. MISER began his duties as professor in the department of geology of the University of Arkansas on May 1.

E. L. BRUCE has resigned from the Canadian Geological Survey, and will be engaged in work for the Whitehall Petroleum Co. during the coming summer. Next fall he will go to Queens University, Kingston, Ontario, as professor of mineralogy.

GENERAL AND MRS. TASKER H. BLISS have announced the engagement of their daughter, Eleanor F. Bliss, to Dr. Adolph Knopf.

J. P. D. HULL, formerly assistant state geologist of Georgia, is now with the Louisiana Oil Refining Corporation, of Shreveport, La.

W. E. MCCOURT, professor of geology at Washington University, has been appointed Dean of the Schools of Engineering and Architecture at that institution.

A. C. BOYLE, JR., formerly professor of geology, mining, and metallurgy at the University of Wyoming School of Mines, has accepted a position as geologist for the Union Pacific Railroad Co., beginning June 15th.

ADOLPH KNOPF, of the U. S. Geological Survey, has been appointed associate professor in physical geology and petrology at Yale University to succeed the late Professor Louis V. Pirsson.

F. H. MOFFITT, of the U. S. Geological Survey, left May 17 for Alaska to carry on investigations in the region west of Cook Inlet with special reference to the occurrence of oil.

A. C. VEATCH, of the Sinclair Oil Co., is in Costa Rica.

H. A. C. JENISON has been placed in charge of the copper division of the Mineral Resources Branch of the U. S. Geological Survey.

BAILEY WILLIS and C. K. Leith were elected members of the National Acadamy of Sciences.

J. S. DILLER, of the U. S. Geological Survey, is in the Apache and San Carlos Indian Reservations, Arizona, to undertake Survey field work in asbestos areas.

W. P. WOODRING, recently employed by the Sinclair Oil Corporation in Panama and Costa Rica, was appointed associate geologist on the U. S. Geological Survey.

F. J. KATZ has been furloughed from the U. S. Geological Survey to accept the position of expert special agent in charge of mines and quarries in the Bureau of the Census, for the 14th Census Statistics.

CHESTER R. THOMAS is geologist for the Amerada Petroleum Corporation of Tulsa, Oklahoma, and in charge of their geologic work in Kansas.

E. F. BURCHARD is on a ten-months' furlough from the U. S. Geological Survey, engaged in geologic work in the Philippines.

C. W. COOKE, of the U. S. Geological Survey, who is temporarily with the Tropical Oil Company arrived at Barrnaca Bermeja, Colombia.

K. F. MATHER has returned to the United States after a six-months' trip to Bolivia where he was engaged in petroleum geology.

H. F. CROOKS is now assistant professor of geology at the Colorado School of Mines.

EDWIN B. HOPKINS, consulting geologist, has opened an office in New York City at 512 Fifth Avenue.

W. S. KEW has resigned from the U. S. Geological Survey to make geological explorations in Columbia for the Vacuum Oil Co.

IRVINE E. STEWART and Fred S. WRIGHT have opened an office for consulting work in the Bank-Electric Bldg., Lewistown, Mont.

JULIAN D. SEARS, of the U. S. Geological Survey, was in Kentucky and West Virginia recently to secure data regarding the quality of the coal and the eastern boundary of the oil and gas fields.

H. D. MISER is filling until the end of the college term, the position left vacant by Professor Drake in the department of mining and geology of the University of Arkansas.

D. E. WINCHESTER has returned to the U. S. Geological Survey to complete his manuscripts on "Oil Shales of the Rocky Mountain Region."

F. B. LANEY, of the U. S. Geological Survey, has been in Salt Lake City, Utah, writing his report on the Seven Devils District, Idaho.

PHILIP S. SMITH, of the U. S. Geological Survey, has returned from a visit to the alkali lakes and sulphur deposits of western Texas.

EUGENE STEBINGER has been granted eight months' leave of absence from June 1, to do geological work for the Carter Oil Co. in southern Bolivia.

A. H. BROOKS recently went to Seattle Washington, where he will act as chairman of Secretary Payne's advisory committee on Alaskan conditions.

W. C. PHALEN recently of the U. S. Geological Survey has accepted a position with the Solvay Process Company of Syracuse, N. Y.

VICTOR G. HILLS, of Denver, Colorago, has been engaged as consulting engineer for the old Dolly Varden mine, Mount Bross, Col.

R. W. STONE, of the U. S. Geological Survey, is visiting magnesite deposits in California and Washington and phosphate mines in Montana and Idaho.

CHARLES A. MITKE has been in the Clifton-Morenci district on professional work for the Arizona Copper Co.

ALBERT D. BROKAW, formerly associate professor of economic geology and mineralogy at the University of Chicago, has opened an office in New York for the practice of his profession as consulting geologist.

J. C. HOYT returned to Washington from Hawaii in April.

A. J. COLLIER, of the U. S. Geological Survey, assisted by M. G. Gulley, is examining the Osage oil field in northeastern Wyoming. Their address is Newcastle, Wyoming.

J. B. REESIDE and C. E. Dobbin, of the U. S. Geological Survey, are continuing work begun last summer in the San Juan coal field, near Aztec, New Mexico.

PROFESSOR C. A. BONINE, of the School of Mines, State College of Pennsylvania, will make field examinations in Wyoming this summer in connection with oil land classification for the U. S. Geological Survey.

FREDERICK R. WEEKES, of New York, and J. J. Stubenford, of Long Beach, California, have been making an examination of the Naildriver Mine at Park City, Utah, for Eastern interests.

VAN H. MANNING resigned on June 1 as director of the U. S. Bureau of Mines to accept the position as director of research with the recently organized American Petroleum Institute.

JOHN STANSFIELD, of Montreal, has gone to New York to take up geological work in connection with oil-field development. His address will be Room 1210, 26 Broadway, New York City.

F. J. S. SUR, petroleum geologist, of San Antonio and Denver is in Montana and Wyoming on inspection trips.

A. W. STICKNEY, the American geologist, reported captured by the Bolsheviki in Siberia is reported by the American consul at Harbin, in a message to the State Department, to be safe in the Altai District of Siberia.

WALTER HARVEY WEED has gone to Cuba.

C. H. COOK has resigned from the Canadian Geological Survey and has accepted a position as geologist for the Associated Gold Fields of Larder Lake.

CHESTER R. THOMAS is geologist for the Amerada Petroleum Corporation of Hulsa, Oklahoma, and in charge of their geologic work in Kansas.

EDWIN A. MCKANNA, formerly geologist with the Mexican Gulf Oil Co., is now with the International Petroleum Co., at Tampico, Mexico.

GEORGE E. BURTON, formerly with the Empire Gas & Fuel Co., has joined the geological staff of the East Butte Mining Co., with offices at Oklahoma City.

DR. HENRY ARTOWSKI, who is representing Polish mining interests in this country was in Washington recently.

A. W. LEHMANN, manager of the Catume Copper Co. in Chile, is making a tour of mining districts of the United States.

HARRISON & EATON, consulting geologists of Denver and Fort Worth, have recently completed an investigation of the oil and gas possibilities in western Oregon, conducted for the Oregon Bureau of Mines and Geology. A report on the results of this examination has been published.

H. LIPSON HANCOCK, general manager, Wallaroo Mining & Smelting Co., Ltd., has sailed for Sydney.

H. A. GUESS, of the A. S. & R. Co., has been in Utah recently visiting the company's properties there.

S. M. SOUPCOFF, mining engineer with the Utah Department of the A. S. & R. Co., has returned to Salt Lake City after an inspection trip to the Nacozari district, Mexico.

FRANK MERRICKS, mining engineer of London, has been elected president of the Institution of Mining and Metallurgy.

L. K. ARMSTRONG and John C. Semple have formed a partnership as consulting engineers, with offices at Spokane.

G. PERRY CRAWFORD, who has been making examinations in the Lordsburg, N. M., district, will sail about May 15 for London, to join a geological expedition to Spitzbergen.

HENRY W. TURNER, mining engineer, Mills Building, San Francisco, is making examinations in central Idaho.

JAY A. CARPENTER, mining engineer, has moved from Tonopah, Nev., to Los Angeles, Cal., where he will practice as consulting engineer at 1006 South Hill Street.

DR. FREDERICK G. COTTRELL has been nominated for director of the Bureau of Mines to succeed Van H. Manning, resigned.

THE UNIVERSITY OF ARIZONA through the Arizona Bureau of Mines is conducting an eight-week field course in geology and mining for advanced students in the Dos Cabezas Mountains in southeastern Arizona, to start July 1st. The region presents interesting geology, and ore deposits. Particulars may be secured from the director of the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona.

THE TASMANIA GEOLOGICAL SURVEY has recently been reorganized and now includes more systematic investigations of ore deposits, underground water supplies, cement ceranine and paint materials, and the study of geologic conditions aflecting all government engineering undertakings. The publications issued are Bulletins, records, reports, mineral resources, water supply papers, and miners circulars. Dr. Loftus Hills is director, and A. M. Reid, P. B. Nye, and H. G. W. Reid are assistant geologists. W. D. Reid is in charge of the laboratory.